(12)

CR 86.007
March 1986
An Investigation Conducted By Waste Energy Technology Corporation
Sponsored By Naval Facilities Engineering Command

NCEL
Contract Report

AD-A168 202

COMPARISON OF SHEAR SHREDDER WITH HAMMERMILL FOR SIZE REDUCTION OF NAVY SOLID WASTE

ABSTRACT The performances of a rotary shear shredder and a vertical shaft hammermill in reducing domestic and Navy solid wastes were compared over an 8-month-period. The shear shredder processed more and a greater variety of material at higher rates, with greater availability, lower O & M cost and longer mean time between maintenance actions than the hammermill. The latter, however, had a longer mean time between failures, higher reliability, a reduced average time required to repair, and produced a finer discharge material.

(Keywords; waste; life cycle cost analysis).

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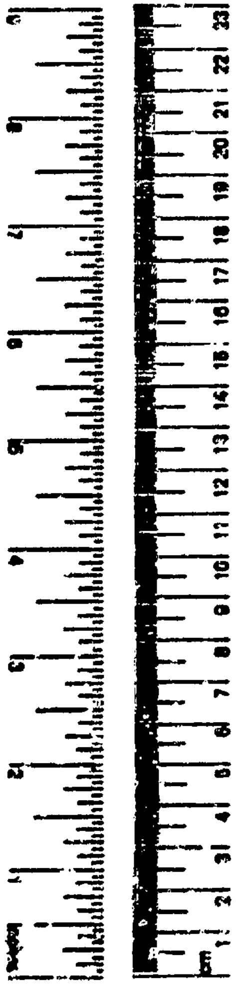
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

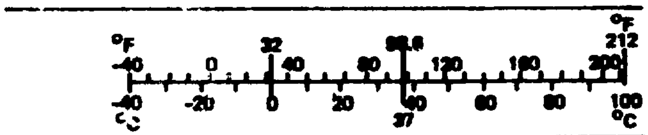
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CR 86.007	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Comparison of Shear Shredder with Hammermill for Size Reduction of Navy Solid Waste		5. TYPE OF REPORT & PERIOD COVERED Final Sep 1983 - Jan 1986
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Bruce E Bond Jerry W Temple Michael F Grubbs		8. CONTRACT OR GRANT NUMBER(s) N62583/83 M T465
9. PERFORMING ORGANIZATION NAME AND ADDRESS Waste Energy Technology Corp One Deangelo Drive Bedford, MA 01730		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Z0371-01-421D/E
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Civil Engineering Laboratory Port Hueneme, CA 93043-5003		12. REPORT DATE March 1986
		13. NUMBER OF PAGES 238
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Naval Facilities Engineering Command Code 032E 200 Stovall Street Alexandria, VA 22332-2300		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

solid waste, shredders, hammermills, shear shredders, refuse derived fuel, RDF

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The performances of a rotary shear shredder and a vertical shaft hammermill in reducing domestic and Navy solid wastes were compared over an 8-month-period. The shear shredder processed more and a greater variety of material at higher rates, with greater availability, lower O&M cost and longer mean time between maintenance actions than the hammermill. The latter, however, had

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TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

TABLE OF CONTENTS
(continued)

TABLE OF CONTENTS
(continued)

LIST OF FIGURES

LIST OF FIGURES
(continued)

LIST OF FIGURES
(continued)

LIST OF TABLES

LIST OF TABLES
(continued)

ACKNOWLEDGEMENTS

The authors express sincere appreciation to the Naval Civil Engineering Laboratory for the sponsorship of this work.

Personnel at the Charleston County Solid Waste Reduction Center were instrumental in their assistance on this research. This includes their cooperation in allowing the shredder performance work to be conducted in their facility, maintaining data, helpful comments, and general tolerance for interference which is caused by research programs.

In addition, the New York State Energy Research and Development Authority (NYSERDA), the Chemung County Milling Station personnel, and the Monroe County officials are thanked for their efforts in the NYSERDA program that was conducted in Elmira, NY and Rochester, NY, and reported as comparative data in this study.

SUMMARY

This study was conducted to compare two types of size reduction equipment for the processing of Navy solid waste. The performances of a 40 ton per hour (TPH), low-speed, high-torque rotary shear shredder and a 12 TPH, high-speed, vertical-shaft hammermill were measured over an 8-month period and compared. Tests were conducted at the Charleston County, SC, Solid Waste Reduction Center (SWRC). Concurrently, Navy waste from the Charleston Naval Base was sampled to determine what material would be difficult-to-shred or unshreddable in each shredder. Life-cycle cost analyses were calculated for each shredder to determine the most cost-effective size reduction technology on a net present value cost-per-ton basis. Finally, the technical and economic data developed in this program were used to project the net present value cost-per-ton of shredding Navy waste.

The shear shredder processed more material and a greater variety of material at higher rates with higher availability than the hammermill. In addition, the shear shredder had lower labor requirements and power consumption per ton of municipal solid waste (MSW) processed as well as a longer mean time between maintenance actions. On the other hand, the hammermill had a longer mean time between failures, a higher reliability, a reduced average time required for repair, a lower repair parts cost, and a decreased labor hour requirement per hour of shredder operation. The hammermill also produced a finer discharge material particle size.

The life-cycle cost analyses for both the Charleston SWRC and a Navy 50 ton per day (TPD) facility, indicated the shear shredder had lower calculated net present value costs per ton than the hammermill. A summary of the results from this program are shown in Table S-1. Abbreviations and acronyms used in this report are listed in Appendix M.

Table S-1

SUMMARY OF RESULTS

Parameter	Shear Shredder	Vertical-Shaft Hammermill
Quantity Processed, tons	48,709	11,820
Daily Throughput, tons		
Average	295	75
Peak	488	150
6-Month Measured Capacity, TPH		
Shredding	68.9	16.7
Shredding and Idle Time	39.3	11.8
Shift	33.0	8.0
Daily Peak Capacity, TPH		
Shredding	114.3	38.3
Shredding and Idle Time	62.0	32.9
Discharge Material Particle Size, inches		
Characteristic	3.4	2.5
Nominal	6.2	5.6
Ability to Process Navy Waste, %	99.75	84.67
5-Month Power Consumption, kwh/ton	3.0	8.4
Calculated Labor, Man-hours/ton		
Operations	0.0352	0.1327
Maintenance	0.0026	0.0083
Management/Other	0.0032	0.0129
Repair	0.0028	0.0082
Calculated Repair Parts Cost, $/ton	$1.51	$0.53
RAM Analyses		
MTBF, hours	422	1,413
Reliability, R	0.98	0.99
PMR, man-hours/hour	0.0736	0.0694
CMR, man-hours/hour	0.1077	0.0941
MI, man-hours/hour	0.1813	0.1635
MTTR, hours	2.844	2.891
MTBA, hours	6.893	7.4[illegible]6
Availability, A_o	82.4%	68.9%
NPV Life-Cycle Cost, $/ton		
Charleston SWRC	$1.72	$2.31
Navy 50 TPD Facility	$1.76	$1.97

PROCESSING INFORMATION

Throughout a 8-month period, the quantity cf material processed by a Cedarapids 5096 low-speed, high-torque, rotary shear shredder and two Heil 42-F high-speed, vertical-shaft hammermills were recorded. Ten samples of discharge material from each of the two types of shredders were collected and analyzed for particle size distribution. During six months of the 8-month period, detailed analyses on operations records, maintenance records, and labor were recorded. Electrical power consumption measurements were also taken, but for only five of the six months due to problems with the recording meters. The periods used in this study were varied as described above to allow the most complete data to be included in this report.

Quantity of MSW Processed and Processing Rates

Throughout the 8-month period, the shear shredder processed four times as much material as the hammermill at over four times the throughput rate. The total production during the period from January through August, 1984, was 48,700 tons for the shear shredder and 11,800 tons for each hammermill. Daily, average throughput was 295 tons and 75 tons, respectively. Maximum daily quantities processed were 488 tons versus 150 tons. Averaging the daily production quantities over a nine hour shift, produced throughput rates of 33 TPH for the shear shredder and 8 TPH for the hammermill.

When the periods during which the shredders were shut off, were subtracted from the hours of the shift, the calculated average processing rates increased to 39.3 TPH and 11.8 TPH for the shear and hammermill shredders. If the operating period was further refined to include only those hours the equipment was activated and actually shredding (as opposed to idling), there were substantially higher calculated feedrate capacities of 68.9 TPH and 16.7 TPH. In general, both shredders performed within the manufacturers' ranges of 35-60 TPH for the shear shredder and 10-25 TPH for the hammermill.

The highest one-day processing rates were 62.0 TPH for the shear shredder and 32.9 TPH for the hammermill, when only the actual operating hours were included in the calculation. Again, if the idle times for each shredder were not included in the calculation, the peak, daily throughput rates were 114.3 TPH for the shear shredder and 38.3 for the hammermill.

Discharge Material Characteristics

The particle size distribution of both shredders' discharged solid waste were very similar. Ten samples of shredded material were collected from each shredder for analysis. The samples were dried, screened through a 12", 8", 6", 4", 2", 1", 1/2", 1/4", and 1/8" sieve series and hand-separated into ten compositional categories. Size distributions were calculated for each category in the solid waste and for the total sample. The characteristic particle size of the shear-shredded MSW was 3.4 inches while the nominal particle size was 6.2 inches. For the hammermill, the characteristic and nominal particle sizes were 2.5 inches and 5.6 inches, respectively.

Both parameters are commonly used to describe particle size distribution. The nominal particle size denotes the size at which 90 percent of the material is finer (10 percent coarser), is a common standard employed in the ore comminution industry, and has been applied often in the solid waste industry. The characteristic particle size is the size at which 63.2 percent of the sample is finer (36.8 percent coarser) and is related to the Rosin-Rammler equation to particle size distributions which has shown relatively good fit with shredded refuse. This describes a general particle size for a sample.

Analysis of Navy Waste

The shear shredder could process nearly all the Navy base solid waste which was delivered to the Charleston County Solid Waste Reduction Center (SWRC). The hammermill could process 85 percent of the Navy waste. Ten truck-loads of Navy waste were hand-sorted into twenty-one compositional categories. Material in each category which appeared unacceptable for shredding was identified, isolated, measured and weighed. One-quarter of one weight percent of the Navy solid waste was considered difficult-to-shred or unshreddable in the shear shredder. Over 15 weight percent of the same waste was determined to be unacceptable for the Heil mill. Problem items for the shear shredder were, normally, larger metal objects. The hammermill unshreddable and difficult-to-shred materials were mainly physically large objects, heavy pieces of metal or ceramic, metal or textile cable and strapping, and flammable and explosive materials.

OPERATIONS AND MAINTENANCE EXPERIENCE

During the analysis period, operations and maintenance records were recorded for each shredder to develop data on reliability, availability, and maintainability (RAM) and information to develop life-cycle cost analyses. Labor, materials, and utilities required by each shredder were monitored and reported. Production quantities were used to calculate the measured parameters on a cost-per-ton basis.

Electrical Power Consumption

The shear shredder required less than one-half the electrical power to shred each ton of solid waste. The kilowatt hours required for shredding were recorded daily for each shredder. Power consumption data were not available for the entire 6-month period. However, plant records were maintained throughout a 5-month period. Total production by the shredders was recorded for the days that power was monitored. Power consumption values were determined for each shredder, both by averaging the daily results and by calculating a weighted-average for the period. The shear shredder consumed 3.0 kilowatt-hours per ton (kwh/ton) and the hammermill consumed 8.4 kwh/ton, determined for the total waste processed through each shredder over the five month period.

Labor and Labor Costs

The hammermill required less labor than the shear shredder, but the shear shredder utilized less labor per ton of waste processed than the hammermill. The labor requirements for each shredder were recorded under operations, routine maintenance, special maintenance/repairs, and management categories. During a twenty-four week period, 1,360 operations man-hours, 99 routine maintenance man-hours, 91 repair man-hours and 122 management man-hours were identified for the shear shredder. During the same period the hammermill required 1,235 operations man-hours, 77 routine maintenance man-hours, 66 repair man-hours, and 120 management man-hours. Clearly, the labor requirements for the hammermill were less in all the categories.

However, during the period in which labor was monitored, the shear shredder processed four times the amount of MSW as did the hammermill. Thus, the labor per ton of waste processed was much less for the shear shredder. Specific labor requirements of the shear-shredding operation were 0.0352, 0.0026, 0.0028, and 0.0032 man-hours per ton of waste processed for operations, routine maintenance, repair, and management categories. Presented in the same order, the calculated values for the hammermill were 0.1327, 0.0083, 0.0082, and 0.0129 man-hours/ton. In all cases the shear shredder was less.

Repairs

The shear shredder required more repairs during the period of observation. More actual repair hours were needed and higher repair parts costs were observed for the shear shredder. Averaged over the production quantities, the hours required for repairs per ton of waste processed were lower for the shear shredder than those for the hammermill. However, even when repair part costs were averaged over the production quantities, the shear shredder repair parts cost per ton of waste processed remained significantly higher than that for the hammermill.

During a six month period beginning in January, 1984, a total of $49,540 and forty hours of downtime were required to keep the shear shredder under repair. The hammermill needed only $5,000 and 24 hours of downtime during the same period to maintain proper operations. Production quantities during those months were over 32,000 tons for the shear shredder and 8,000 tons for the hammermill. The required hours of repair per ton processed, were two and one-half times lower for the shear shredder, 0.0012, compared to 0.0030. On the other hand, averaged over the production quantities, parts costs were much higher for the shear shredder, $1.51/ton versus $0.63/ton for the hammermill. Some of the repairs for the shear shredder were one-time manufacturer upgrading procedures for which the manufacturer absorbed the cost. The labor-hours and costs associated with those repairs were neither reported nor included in these analyses.

RAM Analysis

Reliability, availability and maintainability data were calculated over a six month period and, generally, favored the hammermill shredder. Many of the RAM parameters are calculated using a unit hour of operating time as the basis for comparison. The number of failures, number of repairs, labor requirements, and total analysis period time, were compared to the operating time for each shredder. Values for the number of operating hours between events or the requirement of a specific parameter averaged per unit hour of operation were calculated. In addition, some RAM labor parameters were calculated on a unit ton of production basis. Those data favored the shear shredder, but were not included in the summary of Table S-1 because other calculated labor data were available for a longer, seven month period.

Consumables appear to be better defined on a per-ton basis since they are usually dependent on production quantities. Labor is more difficult to appraise. Normally, one would consider labor hours on a per-hour basis which is especially helpful if labor is a fixed cost at a shredding station regardless of production. However, in comparing two operations when labor hours are specifically allocated between the operations, it appears reasonable to calculate labor on the basis of the cost per ton produced. For shredding solid waste, officials normally try to equate costs on a per-ton basis.

The calculated reliabilities of the shredders were similar at 0.99 for the hammermill and 0.98 for the shear shredder. However, the Mean Time Between Failures (MTBF) was 1413 hours for the hammermill and only 422 for the shear shredder.

Maintainability parameters which utilized labor hours, favored the hammermill shredder. Those which addressed the total time to repair and the time period between maintenance actions, favored the shear shredder. The Preventive Maintenance Ratio (PMR), Corrective Maintenance Ratio (CMR) and Maintainability Index (MI) all favored the hammermill shredder. Values for those parameters, listed first for the hammermill and second for the shear shredder were: PMR (0.0694 and 0.0736), CMR (0.0941 and 0.1077) and MI (0.1635 and 0.1813). The numbers are expressed in units of man-hours per operating hours.

The Mean Time to Repair (MTTR) favored the hammermill shredder while the Mean Time Between Maintenance Actions (MTBMA) favored the shear shredder. Thus, the shear shredder required longer periods to repair its breakdowns, but ran for longer periods without requiring maintenance. MTTR for the shear shredder was 1.77 hours; the hammermill was less at 1.04 hours. MTBMA was 8.89 hours and 7.44 hours for the shear shredder and hammermill, respectively.

Equipment availability calculations favored the shear shredder if Navy guidelines are strictly followed. The guidelines indicate the total operating hours of the shredder were to be compared to the total time of the shift. Then, the calculated availabilities were 0.82 for the shear shredder and 0.69 for the hammermill. However, much of the time when the hammermill was not being operated, it could have been operated. When those "no-fault" hours were included in the analyses for both shredders, the hammermill had slightly higher availability, 0.93 compared to 0.92 for the shear shredder.

Safety Considerations

A study on safety must be conducted over large production quantities in order to have a reasonable probability for an explosion of either minor or major impact to occur. Processing during this study fell below the thresholds typically expected for hammermill explosions: 50,000 tons for a minor explosion and 150,000 tons for a major explosion. Nonetheless, during the analysis period the Charleston County records for the hammermills listed an explosion occurred on February 23 and a fire was caused on July 13. No events of explosion or fire occurred in the shear shredder during this study. This is believed to be caused by the low-speed shredding action of the shear shredder cutters. Fires have been reported in a New York State Energy Research and Development Authority (NYSERDA) study on shear shredders performed in Elmira, NY. Explosions have never been reported during the shear-shredding of municipal solid waste (MSW). Due to these preliminary findings, it is believed there may be inherent safety advantages associated with the slow-speed shear shredders as compared to the high-speed hammermill shredders.

LIFE-CYCLE COST ANALYSIS

The present value cost per ton of waste shredded for a 20-year life-cycle was calculated utilizing the information developed in this program for the Charleston County SWRC shredders. The cost per ton of shear-shredding was less than that for hammermill shredding. Calculations were made employing two scenarios. In the first scenario, the entire facility capital cost including the shredder was considered a sunk cost. In the second scenario, the capital cost of the facility was included. The former approach was preferred for the Charleston facility, because it more accurately portrayed the real situation at the SWRC where everything was already on site. The hammermill was installed at the time of facility construction while the shear shredder was retrofit prior to initiation of this program. By excluding the capital costs, a more valid comparison of the cost to operate and maintain each shredder was produced. The latter approach was preferred for the Navy case, based on the assumption the entire shredding facility would have to be built. Then, differences in the construction and installation costs for each shredder as well as the shredder price would be reflected in the overall cost. In all analyses, a 5-day/week and 50-week/year were assumed for the shredding facility to produce 250-days/year of operations. Neither case represented a retrofit installation into an existing building, whereby the cost of the new shredder and a salvage value of the old shredder would be included.

In Charleston County, all the shredded MSW is landfilled. The driving forces for shredding prior to landfilling are the reduced costs resulting from a decrease in the cover material needed and extension of the landfill life caused by the reduced volume needed for the higher bulk density, shredded MSW. A differential cost of $1.00/ton was assumed as the benefit for landfilling shredded waste.

Although the total life cycle cost associated with hammermill-shredding was less than that for the shear-shredding operation, the quantity of material processed by the shear shredder was four times that of the hammermill, resulting in a cost-per-ton for the shear-shredding operation that was less expensive. Calculated life-cycle costs, excluding the capital facility, were $1.60/ton for the shear shredder and $2.46/ton for the hammermill. When the facility costs were included, both types of shredder operations increased in cost. The least expensive, again, was the shear shredder at $2.34/ton compared to $4.62/ton for the hammermill. The quantities of MSW processed over the twenty year period were 1,426,420 tons and 361,040 tons for the shear shredder and the hammermill shredder, or approximately 71,320 tons per year and 18,050 tons per year, respectively.

PROJECTED LIFE-CYCLE COST ANALYSIS

All the work in this contract was conducted to obtain enough data to project the present value, life-cycle cost of a Navy 50 ton per day (TPD) shredding facility. Although most of the results on a per unit ton processed basis appeared to favor the shear shredder, an analysis was done on both the shear shredder and the hammermill shredder in light of the fact the low, 50 TPD processing requirement for the Navy facility better matched the average throughput capacity of the hammermill shredder. In spite of that fact, the results of this projection showed the shear shredder to be the lower-cost alternative.

For this analysis, it was preferred to include the facility capital cost. Generally, it was believed a Navy shredding station would be a new facility. The shredding station was viewed as the front-end processing for an existing heat recovery facility. Thus the coarse-shredded refuse derived fuel (RDF) produced by each shredder was assigned a value of $5.00/ton. Also, in this analysis, the disposal costs for unshredded materials was considered to be the actual Charleston County rate of $8.60/ton rather than a differential cost ($1.00/ton benefit for landfilling shredded MSW as opposed to unshredded MSW) used in the Charleston SWRC analysis. It was assumed that all shredded material was used as a fuel. Thus, if a $5.00/ton revenue was applied to the shredded material, then the $1.00/ton benefit could not be.

In this analysis the total annual production through each shredder was approximately 12,500 tons. However, since both shredders could process at higher rates than 50 TPD, the shredders were assumed to operate for less hours during each day at average processing rates. This was a better alternative than processing the full shift at lower than optimum rates. Had that approach been taken, the fixed costs per hour, such as operating labor would have increased on a cost per ton basis.

This resulted in a substantial cost savings for the shear shredder and produced a net present value cost for size reduction of $0.44 per ton excluding the facility capital cost. With the same assumptions, the calculated net present value cost per ton for the hammermill shredding was $1.12. However, if the facility were not already in existence and the capital outlay were required which is the expected case for the Navy, the costs of shredding would be increased to $4.27/ton for the shear shredding operation and $4.36/ton for the hammermill operation. In this scenario, the facility capital cost dominates the life cycle net present value costs due to the low tonnages processed by each shredder.

CONCLUSION

The shear shredder has only recently been applied to the size reduction of municipal solid waste. This study was one of the first to monitor the performance of a shear shredder on MSW. Data correlated well with short-term testing conducted by the New York State Energy Research and Development Authority in Chemung County, NY.

Throughout this study the shear shredder appeared to offer a more economical operation compared to the hammermill for shredding Navy waste. Parts costs for the shear shredder were higher, but labor and electrical costs per unit ton processed were low enough to offset the high parts costs. Many parameters in this study were sensitive to the quantity of material processed. For example, operations' labor requirements were nearly identical for the two mills, but the higher throughput capacity of the shear shredder resulted in a much lower calculated man-hour per ton ratio than for the hammermill. The measured shear shredder processing rate and total production was a factor of four higher than that of the hammermill.

For cost analyses which used the high level of production of the shear shredder, it was expected the cost per ton of shear-shredding would be less than that for hammermill-shredding. Nonetheless, the shear shredder also appeared to have a lower projected cost per ton at the lower, 50 TPD Navy facility that was modeled. In the 50 TPD Navy facility case, the shear shredder was assumed to be operated for only a small portion of the day to fully service the facility. This had the effect of reducing the operations and maintenance costs.

If the Navy were to consider a shredding facility to process solid waste prior to combustion, it should consider the shear shredder as a viable alternative to hammermill shredding. The shear shredder has been shown to accept a wider range of infeed materials and produce a discharge material particle size comparable to the vertical-shaft hammermill shredder, at a lower projected life-cycle cost per ton processed.

Section 1

INTRODUCTION

BACKGROUND

The Navy has been working on projects in Refuse-Derived Fuel (RDF) process evaluation for co-firing and for preprocessing of waste prior to incineration in a Heat Recovery Incinerator (HRI). Typical commercial solid waste processing facilities include shredding for size reduction and homogenization of the waste. Information gathered in this study on two full-scale, commercial size reduction equipment at the Charleston County Solid Waste Reduction Center (SWRC) in Charleston, SC, was used to identify the most operable and cost-effective concept for size reduction in RDF preparation for the Navy.

The SWRC has two types of primary shredders; one Cedarapids 5096 low-speed, high-torque shear shredder and two Heil 42-F vertical shaft, high-speed hammermills. The shear shredder has a dedicated feed conveyor, discharge conveyor, and compactor. The hammermills have individual feed conveyors, but share a discharge conveyor and compactor. Comparative data would be developed for each type of shredder and be used to develop life-cycle cost data for a 50 TPD Navy waste size reduction operation. This was accomplished by following a four element plan as presented in the next section.

OBJECTIVES

The program objectives were divided into four areas: (1) characterize Navy waste processed at the SWRC; (2) obtain operations, maintenance, and RAM (reliability, availability and maintainability) data on the shear shredder and the hammermill shredder at the SWRC and compare their performances; (3)

determine the life-cycle cost of size reduction at the measured throughput rate for both equipment at the SWRC; and (4) project the life-cycle cost of size reduction for a 50 ton/day (TPD) facility, using the most cost effective equipment concept. The objectives were met by following the Scope of Work as detailed below.

SCOPE OF WORK

The scope of work used to achieve the four objectives given above is given for each task item.

<u>Task 1: Characterization of Waste</u>

Navy waste delivered to the SWRC was characterized over a 26-week period. On a randomly selected day of the week, one truck-load of Navy waste delivered to the SWRC was selected at random. The truck was weighed, emptied at a cleaned location on the tipping floor, and reweighed to determine the quantity of waste. The discharged waste was hand-sorted by separating the waste into specific categories. The categories were: paper; plastic -- light, heavy, and other; rubber -- tires and other; cardboard; textiles; wood -- pallets and other; miscellaneous organics; glass; inerts and ceramics; ferrous -- cable/strapping and other; nonferrous -- cable and other; and other and special wastes -- aerosol cans, paint, solvents, oil, and insulation.

From those categories were identified those wastes which could not be processed in each shredder. All but one of the categories of waste were weighed with the nonbulky, major component calculated by difference. This process was repeated nine times throughout the 26-weeks. Based upon the 10 data points for the Navy waste, the average Navy waste composition was calculated as percentages of the total.

Task 2: Performance Evaluation

Over a 36-week period the following data was determined for the shear shredder and for the hammermill shredder:

- Size distribution of reduced waste by sieve analyses, utilizing 12", 8", 6", 4", 2", 1", 1/2", 1/4", and 1/8" screens, averaged over ten samples taken over a 36-week period,

- power consumption averaged over a 22-week period calculated on a daily basis in units of kwh/ton processed,

- operating man-hours andman-hours/ton of waste processed, averaged over a 26-week period,

- optimum processing capacity, averaged over the operating hours for each day during the 36-week period, in units of tons/hour,

- repair man-hours and man-hours per ton ofwaste processed averaged over the 26-week period,

- cost of parts used per ton of waste processed averaged over the 26-week period and reported in $/ton,

- downtime for repairs, totaled over the 26-week period and reported in units of hours,

- idle time when the equipment was operational, totaled over the 26-week period and reported in hours, and

- idle time when the equipment was not operational, totaled over the 26-week period and reported in hours.

The performance of the shear shredder was to be compared to that of the hammermill at the SWRC and to data previously obtained by the contractor on similar types of size-reduction equipment. The data was also to be used to describe the quality of the size-reduced product as determined by the contractor in previous tests conducted outside the scope of this work. The quality was to be assessed as the potential yield and ash content of RDF produced from the shredded SWRC solid waste after subsequent air classification or trommelling operations. Finally, the reliability, availability, and maintainability (RAM) of the shear shredder and the hammermill were to be determined over a 6-month period utilizing Navy procedures (1).

Task 3: Life-Cycle Cost

The life cycle costs of the shear shredder and the hammermill shredder were to be determined at the measured throughput rate of the SWRC, utilizing the Navy procedures specified (2). Results were to be reported in units of $/ton.

Task 4: Projected Life-Cycle Cost

Based upon data developed in this program and previous experience by the contractor, the projected life-cycle cost of size reduction for Navy waste was to be determined using the most cost-effective equipment concept. The design criteria was for a 50 TPD facility and the results to be reported in units of $/ton.

In summary, the four task approach was designed to project the life-cycle cost of size reduction of Navy waste. This was accomplished by, first, characterizing the Navy waste for composition and the ability to shred the waste in the shear shredder and the vertical-shaft hammermill at the SWRC. Second, the two shredders were evaluated for measured performance during operations of the SWRC to determine operations and maintenance data. Third, calculated life-cycle costs for the shredders at the SWRC were made, based upon the shredder performance data. Fourth, and finally, the life-cycle cost analysis was adjusted to accommodate the Navy waste composition to develop the cost for processing the Navy waste.

A brief description of each of the shredders is given in the next section to help readers understand the reasons the performance between the two shredders will vary.

SHREDDERS UTILIZED

Two types of commercial-scale shredders were utilized in this program. The first, was a Cedarapids 5096 low-speed, high-torque, rotary shear shredder. The second, was a Heil 42-F high-speed, vertical shaft hammermill. When the SWRC went on-line on July 1, 1974, it utilized three Heil shredders (3). One was a Heil 92-A (500-hp, 40 TPH) and two were Heil 42-F's (250-hp, 20 TPH). In the afternoon of October 2, 1981, an explosion occurred in the Heil 92-A. It was recommended, and Charleston County proceeded, to install a shear shredder as a replacement for the larger hammermill. In addition, the SWRC would continue to utilize its two, smaller Heil 42-F hammermills. An overall, general arrangement view of the three shredders in the SWRC is shown in Figure 1-1. A comparison of the shredders utilized is shown in Table 1-1.

Cedarapids 5096 Shear Shredder

The Cedarapids 5096 shredder (Figures 1-2 and 1-3) is a low-speed, high-torque, rotary shear shredder. It weighs 40,000 pounds and can be installed on a simple steel beam support structure. The shredder has a working area of 96 inches long and 50 inches wide by 26 inches deep. In this area, are two parallel, counter-rotating, keyed shafts driven by externally mounted hydraulic motors. Cutters are installed on each shaft to

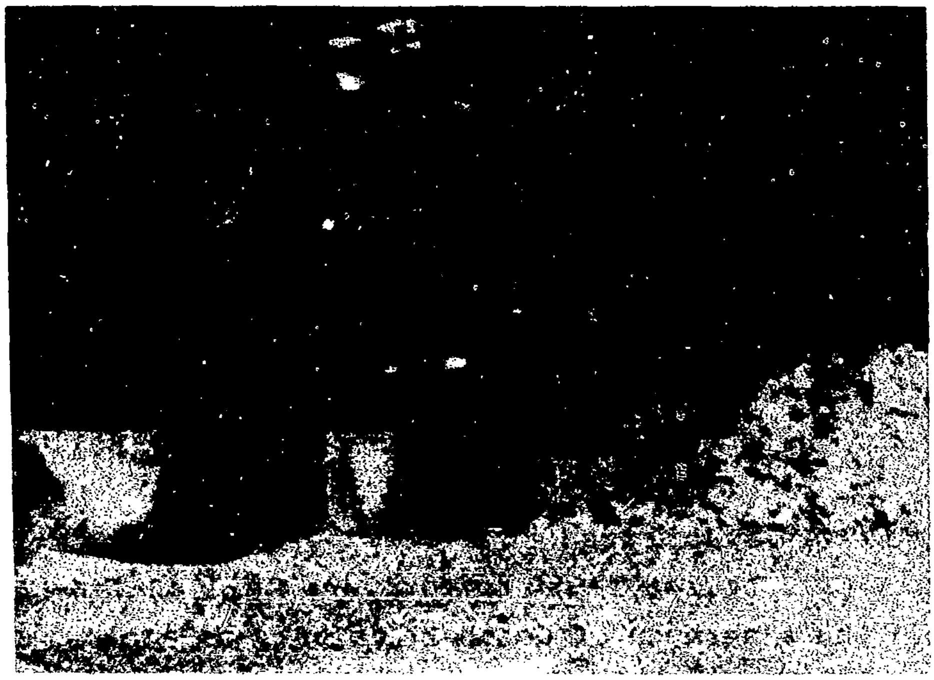


Figure 1-1. Overall general arrangement view of the three shredders at the Charleston County SWRC. To the left, are the infeed conveyors to two Heil 42-F vertical-shaft hammermills. To the right, is the infeed conveyor to the Cedarapids 5096 Shear Shredder.

Table 1-1

COMPARISON OF SHREDDERS UTILIZED

	Cedarapids 5096	Heil 42-F
Overall Dimensions, l x w x h (inches)	175 x 74 x 52	133 x 124 x 118
Infeed Opening (inches)	50 x 96	36 x 66
Weight (pounds)	40,000	31,400
Shafts	2 - horizontal	1 - vertical
Motor Horsepower	2 x 200	1 x 250
Drive	Hydraulic	V-Belt & Sheave
Shaft RPM	1 - 33 1 - 43	1200 nominally, both clockwise & counter
Cutters/Hammers Weight (pounds)	24 cutters 400, approximately	38 hammers 14.25
Tip to Tip Distance (inches)	26	from 27 to 42 depending on location
Procedure for Difficult-to-Shred	Reverse, or jam & remove manually	Reject, or jam & remove manually
Rated Capacity (TPH)	35 - 60	10 - 25

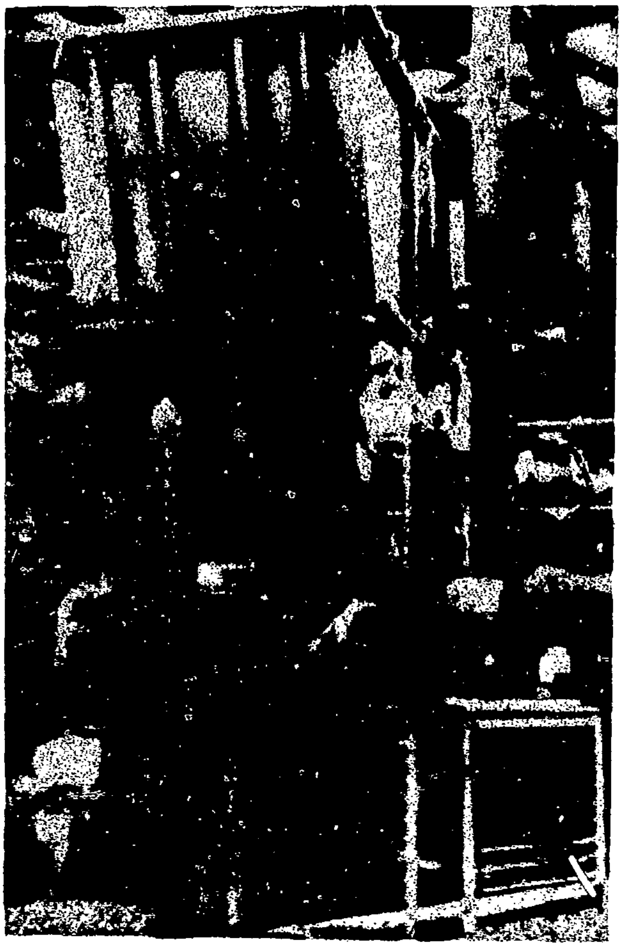


Figure 1-2. Cedarapids 5096 Shear Shredder. Shredder is installed on a structural steel platform. Working part of shredder is between platform floor and lower railing, between people. Hydraulic motors are seen to right of column between railings. Upper part of figure is feed chute and hopper. On floor in front of shredder is power pack, including electric motors, hydraulic pumps, and oil cooling radiators.

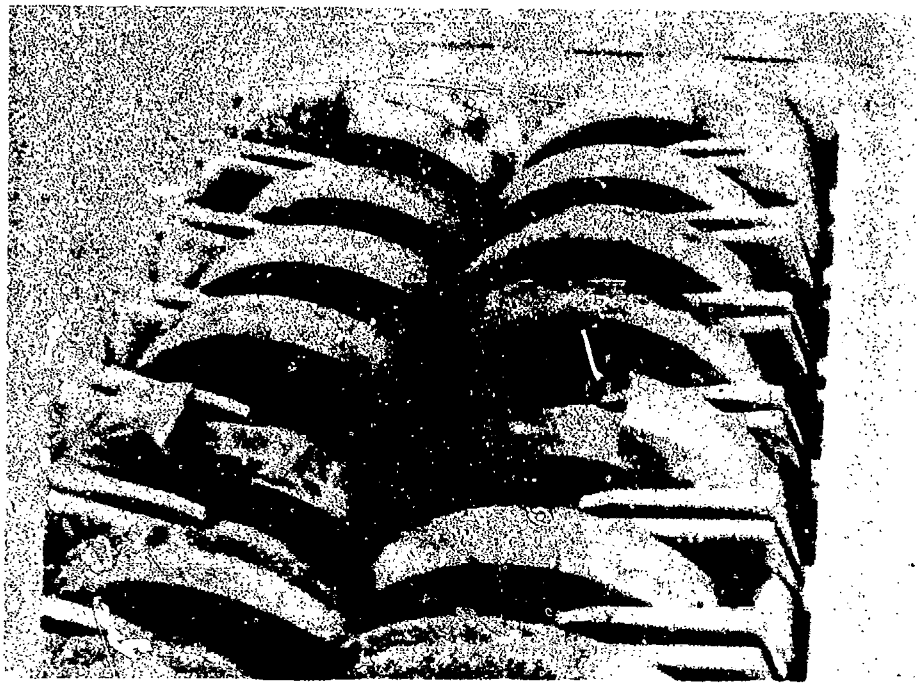


Figure 1-3. Interior view of Cedarapids 5096 shear shredder showing 4-inch cutters.

shred the refuse. Each cutter has the appearance of a disc, 26.5 inches in diameter, with raised "teeth" in the radial direction. The centerline to centerline distance between the shafts is approximately 20 inches such that cutters from one shaft overlap those of the other shaft. Cutters are alternately installed on the two shafts with smaller diameter spacers such that a cutter on one shaft is opposed by a spacer on the second shaft. The spacers keep the cutters in line and help control discharge-material particle size. The thickness of the cutters and spacers controls the particle size in a direction parallel to the shafts. In the direction perpendicular to the shafts, the openings through which solid waste is shredded vary between a maximum of approximately 3.5 inches, just before the cutter tooth has passed the spacer, and a minimum of 1/2 inch when the cutter tooth is at the spacer.

A separate, skid-mounted power pack weighing 10,000 pounds drives the hydraulic motors. Each hydraulic motor is individually driven by a hydraulic pump, powered by a 240 v - 3Ø - 60 cycle, 200-horsepower electric motor. An electric panel on the end of the skid houses the shredder control, including switches for activation of the power, step-start motor windings, hydraulic pump control, local control switches, and safety interlocks.

One shaft of the shredder operates at a lower speed, about 33 rpm, while the other operates at about 43 rpm. Although the shaft speeds can be adjusted, they are controlled by a single potentiometer and maintained at a constant ratio. The difference in rotation speed helps produce more uniform wear on the cutters by constantly varying the circumferential surface on which material is broken. Solid waste is pulled through and cut in the area between the shafts by the cutter teeth. If an item is difficult to shred, the hydraulic pressure rises to cut the material. High pressure is maintained as the shafts start to slow down. A speed sensor is installed on each shaft. When either speed sensor reaches a preset lower limit, a relay is activated which causes the hydraulic system-flow to automatically reverse. The shafts reverse rotation and lift the material free. Metal cleaning fingers are fixed to the side wall and extend above and below the spacers (between the cutters) to help free material such as metal which can be compressed between the cutters. After a timed delay, the hydraulic flow reverses to the normal direction and shredding resumes.

Cutters are manufactured in four orientations: with the cutter tips at 0°, 45°, 90°, and 135° from the keyways. The cutter width tested in this program was 4-inches. Cutters are also available in 2-inch widths which can be stacked to form any width which is a multiple of 2-inches.

Manufacturer's data on the Cedarapids 5096 Shear Shredder is included in Appendix A.

<u>Heil 42-F Hammermill Shredder</u>

The Heil 42-F shredder is a high-speed, vertical-shaft hammermill, Figure 1-4. It weighs approximately 25,000 pounds (15,700 without hoods, motors and other peripherals) and requires reduced foundation requirements compared to a horizontal-shaft hammermill. The shredder has a working chamber that is 74-inches long, conical in shape at the top, and cylindrical in shape at the bottom. In this area is a rotor assembly of stacked motor hubs and discs to permit fourteen layers of hammers with provisions for a wide variety of hammer patterns. A total of 38 hammers are usually used for primary shredding of municipal solid waste. Hammers are relatively thin and flat, each weighing about 14 pounds. Figure 1-5 shows an interior view of a Heil 92-B vertical shaft hammermill. The Heil 92-B is much larger than the Heil 42-F (cavity, horsepower, hammers) having a capacity of 60-100 TPH but operates under the same principle.

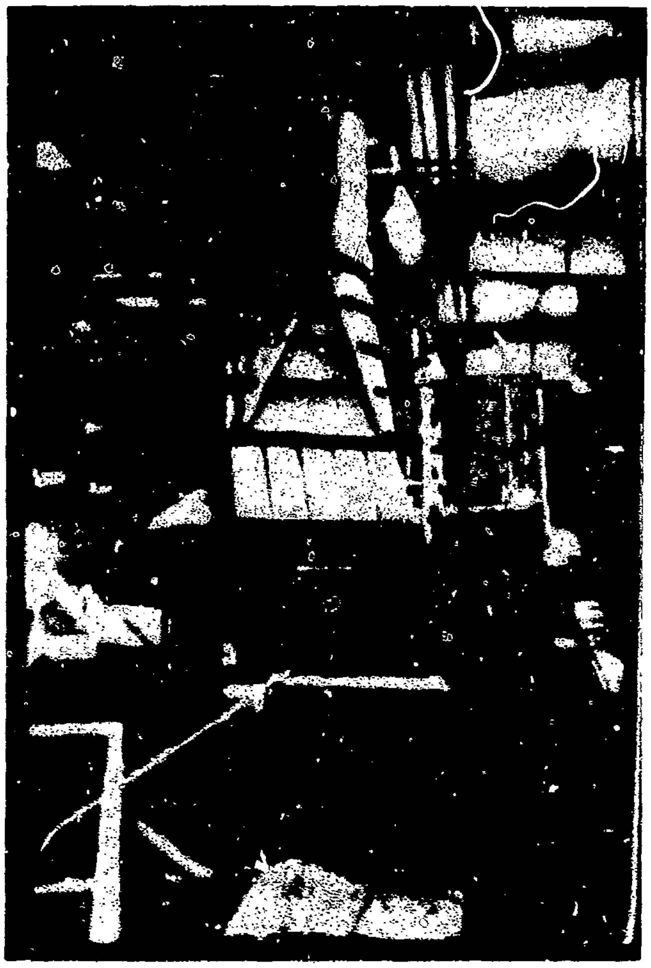


Figure 1-4. Overall view of the Heil 42-F vertical shaft hammermill.

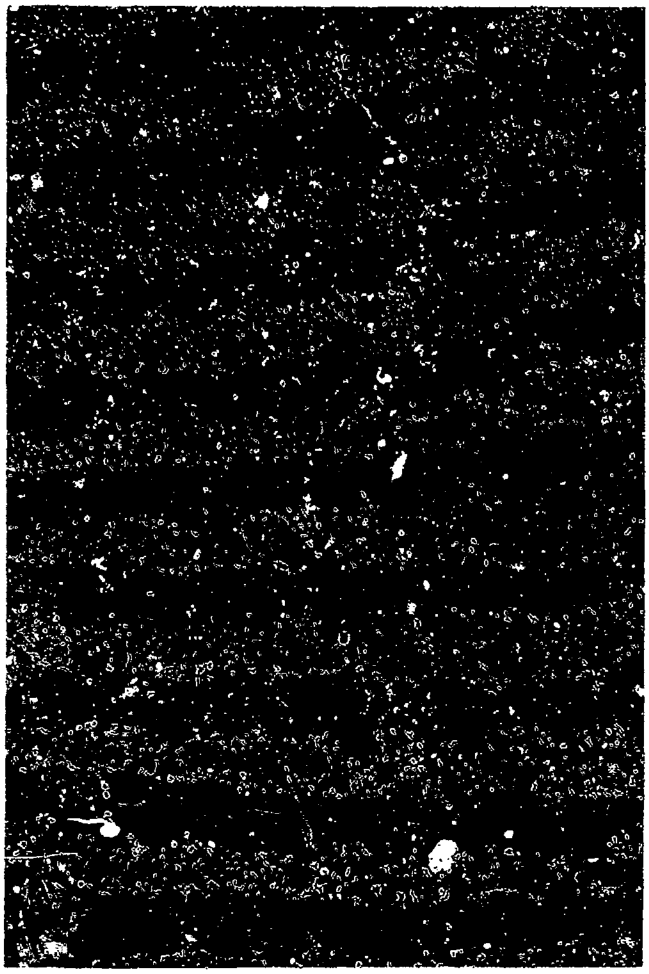


Figure 1-5. Interior view of a Heil 92-B vertical shaft hammermill.

There are no grates in the Heil shredder. Size reduction is accomplished by impact of the hammers and grinding between the hammers and the shredder wall or between the hammers and breaker bars. The entire shredder housing is protected with replaceable liners. In the conical, prebreak section, shredding is mainly by hammer impact. As the housing diameter is reduced, greater size reduction takes place until the neck section is reached. This is a location in the shredder, between the conical and the cylindrical sections, where the inner diameter of the housing is its smallest. Material which cannot easily be ground to a size to fit through the neck can be rejected through a ballistic ejection chute at the top of the shredder.

Material which passes through the neck section enters the third-stage of grinding where material is battered by the hammers against breaker bars. The final shredded product is discharged horizontally through a chute, which can be located at twelve locations relative to the infeed chute, each location 30° from one another. Particle size is controlled by the number, pattern, and shape of the hammers.

The shredder shaft is designed for dual direction rotation to allow more even wear before replacement of hammers. Only certain hammer locations experience heavy wear. Usually partially worn hammers from above the neck are moved to higher tiers where the wear environment is less, minimizing the total number of hammers to be replaced during each maintenance action.

The shredder is powered by a 250 hp, 3Ø - 60 cycle, 460 volt, vertical shaft induction motor, through a multiple v-belt and sheave drive. The motor direction is manually reversed and is protected by three normally closed heat sensors.

Manufacturer's data on the Heil 42-F hammermill is presented in Appendix B.

Section 2

RESULTS

This section presents the results of Task 1, Characterization of Waste, and Task 2, Performance Evaluation. The first topic includes analyses on ten truckloads of Navy waste which totaled 48,920 pounds. The analyses were a determination of composition and an assessment on the type and quantity of Navy waste that would be difficult to shred or unshreddable in each of the shredders.

The second topic is a characterization of the Cedarapids 5096 shear shredder and the Heil 42-F vertical-shaft hammermill. It includes operations information such as the operating hours, tons processed, the size distribution of the discharged MSW, power consumption required to produce the shredded MSW, average processing rates, and idle time when the equipment is both operational and not operational. In addition, maintenance information is included in this characterization. Here, information such as downtime for maintenance, downtime for repairs, repair man-hours per ton of refuse processed, and repair parts costs per ton of waste processed are noted. Previously obtained operations information on similar shredders are included in this section and a reliability, availability and maintainability (RAM) analysis is included for each of the SWRC shredders.

CHARACTERIZATION OF WASTE

Over a 36-week period, ten samples of Navy waste were analyzed in detail. Analyses were conducted to determine Navy waste composition and to determine the unshreddable and difficult-to-shred portions of the waste for each shredder. Individual, refined data sheets are shown in Appendix C. Raw data is presented in Appendix D.

Composition of Navy Waste

Ten samples of Navy waste adding to a total of 48,918 pounds, were analyzed between February 22, 1984 and August 22, 1984. The waste had an average, calculated bulk density in the trucks of 5.05 pounds/cubic foot and a weighted average of 5.18 pounds/cubic foot. The average composition of the waste is shown in Table 2-1. The waste composition was divided into five major categories and multiple smaller categories. Composition of the major categories were: Organics--97.06%, Inerts--1.22%, Ferrous--0.89%, Nonferrous--0.55%, and Other/Special--0.28%. The organic content of the Navy waste, found in the study, was much higher than typical municipal solid waste which is on the order of 80% organic materials. The Other/Special category mainly includes materials that were considered flammable or explosive. One exception in that category is insulation, which was a composite material and did not seem to fit into any of the other categories. Excluding the insulation, the total dangerous waste was less than 1% by weight.

Ease of Shredding Navy Waste

A summary of the unshreddable and difficult-to-shred objects in the Navy waste is shown in Table 2-2. Of all the Navy material analyzed, the shear shredder was expected to be incapable of shredding 0.04% of the waste and to have difficulty shredding an additional 0.21% of the waste. For the same waste the Heil 42-F hammermill was believed to be unable to shred 10.41% of the waste and to have difficulty shredding 4.92% more of the waste.

Most of the troublesome waste for the Heil shredder was either: large, and could not easily fit into the shredder feed chute;

Table 2-1

ANALYSIS ON NAVY WASTE SAMPLES
TRUCK BULK DENSITY AND COMPOSITION

		TOTAL SAMPLE	
		Wet Weight (lbs)	Wet Weight %
Volume, Cu.Ft.	10800		
Usage	0.88		
Net Volume, Cu.Ft.	9450		
Density, Lb./Cu.Ft.			
Average	5.05		
Weighted Average	5.18		
COMPOSITION			
PAPER		13139	26.86
PLASTIC			
Light		2036	4.16
Heavy		237	0.48
Other		117	0.24
RUBBER			
Tires		2	.00
Other		665	1.36
CARDBOARD		13973	28.56
TEXTILES		860.5	1.76
WOOD			
Pallets		2140	4.37
Other		3556	7.27
MISC. ORGANICS		10755	21.99
SUBTOTAL ORGANICS		47480.5	97.06
GLASS		330.5	0.68
INERTS/CERAMICS		266	0.54
SUBTOTAL INERTS		596.5	1.22
FERROUS			
Cable/Strapping		83	0.17
Other		351	0.72
SUBTOTAL FERROUS		434	0.89
NONFERROUS			
Cable		29	0.06
Other		242	0.49
SUBTOTAL NONFERROUS		271	0.55
OTHER/SPECIAL			
Aerosol Can		7	0.01
Paint		4	0.01
Solvents		10	0.02
Oil		15	0.03
Insulation		100	0.20
SUBTOTAL OTHER		136	0.28
TOTAL		48981	100.00

Table 2-2

SUMMARY OF ALL NAVY WASTE SAMPLES
WEIGHT OF UNSHREDDABLE AND DIFFICULT-TO-SHRED OBJECTS
(Data are in pounds)

Component	Total	UNSHREDDABLE		DIFFICULT-TO-SHRED	
		Shear	Heil	Shear	Heil
PAPER	13139	0	0	0	360
PLASTIC					
Light	2036	0	0	0	0
Heavy	237	0	0	0	0
Other	117	0	0	0	0
RUBBER					
Tires	2	0	0	0	0
Other	665	0	430	0	0
CARDBOARD	13973	0	1540	0	605
TEXTILES	860.5	0	62	62	75
WOOD					
Pallets	2140	0	1715	0	95
Other	3556	0	1224	0	1125
MISC. ORGANICS	10755	0	0	0	0
GLASS	330.5	0	0	0	0
INERTS/CERAMICS	266	0	0	0	60
FERROUS					
Cable/Strapping	83	0	0	0	0
Other	351	0	100	40	77
NONFERROUS					
Cable	29	0	0	0	0
Other	242	19	19	0	12
OTHER/SPECIAL					
Aerosol Can	7	0	2	0	0
Paint	4	0	0	0	0
OTHER/SPECIAL					
Solvent	10	0	1	0	0
Oil	15	0	0	0	0
Insulation	100	0	0	0	0
TOTAL	**48918**	**19**	**5093**	**102**	**2409**
PERCENT	**100.00**	**0.04**	**10.41**	**0.21**	**4.92**

flexible, and could wrap around the rotor; made of tough material, which may not be rejected through the ballistic ejection chute; or was considered explosive. The problem materials for the shear shredder were nylon webbing, steel steps and aluminum blocks. Summaries of the unshreddable and difficult-to-shred objects are provided in Table 2-3 through 2-6. Table 2-3 and 2-5 list the unshreddable objects for the shear shredder and the hammermill, respectively. The difficult-to-shred objects are listed in Table 2-4 for the shear shredder and Table 2-6 for the hammermill shredder.

PERFORMANCE EVALUATION

This section includes detailed operations and maintenance information on both the shear shredder and the hammermill. Operations data include information on the shredded discharge product, operating capacities, power consumption and labor requirements. Maintenance data include maintenance hours, man-hours, and repair parts costs. Performance of the Charleston, SC, shredders are compared to the performance of two shredders in Chemung County, NY. A reliability, availability and maintainability analysis is presented for the Charleston, SC shredders.

Processing Capacity

The shredders were operated from January to September, 1984, to determine processing capacity. The average, daily throughput rates were determined by maintaining a record of the tons processed through the shredder and the operating hours of the shredder during each day's shift. On Mondays, Tuesdays, Thursdays and Fridays the normal shift for the plant was nine hours. On Wednesdays the shift was scheduled for six hours, due to a decrease in the amount of solid waste collected. There were no weekend operations.

Table 2-3

UNSHREDDABLES -- SHEAR SHREDDER

Sample	Date	Source	Component	Weight (lbs.)	Size (Inches) LxWxH	Description
1.	2/22/84	Supply Center, Bldg 19B	None	-		
2.	3/14/84	Bldg 1601 (Northside)	None	-		
3.	3/21/84	Bldg 228 CIA Area	None	-		
4.	5/16/84	Bldg 1603	None	-		
5.	5/23/84	Bldg 67	Aluminum Blocks	19	4"x6"x8"	2 solid Al blocks
6.	5/30/84	Pier Q	None	-		
7.	7/11/84	Pier M	None	-		
8.	7/25/84	Bldg 1502	None	-		
9.	8/15/84	Bldg 25	None	-		
10.	8/22/84	Bldg 67	None	-		

Table 2-4

DIFFICULT-TO-SHRED ITEMS FOR THE SHEAR SHREDDER

Sample	Date	Source	Component	Weight (lbs.)	Size (Inches) LxWxH	Description
1.	2/22/84	Supply Center, Bldg 19B	None	-		
2.	3/14/84	Bldg 1601 (North Side)	None	-		
3.	3/21/84	Bldg 228 CIA Area	None	-		
4.	5/16/84	Bldg 1603	Textiles	62	1"0x900'L	2 Rolls nylon webbing
5.	5/23/84	Bldg 67	None	-		
6.	5/30/84	Pier Q	Steel Steps	40	6"x8"x3"	Steps, 5/16" thick
7.	7/11/84	Pier M	None	-		
8.	7/25/84	Bldg 1502	None	-		
9.	8/15/84	Bldg 25	None	-		
10.	8/22/84	Bldg 67	None	-		

TABLE 2-5

UNSHREDDABLES — HEIL HAMMERMILL

Sample	Date	Source	Component	Weight (lbs)	Size (inches)	Description
1.	2/22/84	Supply Center Building 19B	None			
2.	3/14/84	Building 1601 (Northside)	None			
3.	3/21/84	Building 228 CIA Area	None			
4.	5/16/84	Building 1603	Aerosol Can	1	4"Dx10"H	Explosive - flammable liquid
			Textiles	62	1"Wx21"D	Cases nylon webbing
			Wood Pallets	450	36"x48"x5"	Will not fit into shredder
			Cardboard	800	30"x36"x60"	Large,Heavy Boxes
5.	5/23/84	Building 67	Wood Pallets	385	36"x40"x5"	Will not fit into shredder
					36"x36"x4"	
			Wood Crate	39	20"x39"x18"	
			Cardboard	150	36"x48"x36"	Will not fit into shredder
			Aluminum Blocks	19	4"x6"x8"	2 Solid Al blocks
			Steel	8	1"x4'	Reinforcement Rod
			Steel Pipe	3	3/4"x10'	
			Aerosol Can	1	4"Dx10"	13-oz. Primer Paint
6.	5/30/84	Pier Q	Rubber Matting	430	12"Dx36"L	Rolls
			Steel Steps	40	6"x18"x3"	Steps 5/16" thick
			Alcohol	1	2"x6"x8"	Can of Flammable Liquid
7.	7/11/84	Pier M	Steel Drums	40	30"Dx40"L	Used for Solvents
			Wood	450	3'x6'x1/4"	Boxes and Plywood
8.	7/25/84	Building 1502	Wood Pallets	670	36"x48"x6"	Large
			Wood	275	2"x4"x16'-18'	
			Cardboard	400	42"x40"x36"	Large Boxes
9.	8/15/84	Building 25	Wood	210	4"x36"x36"	Pallets
			Metal Cans	9	10"x8"x14"	Flammable-Paint Thinner
10.	8/22/84	Building 67	Wood	460	18"x6'	Boxes & Heavy Pallets
			Cardboard	190	26"x39"x3"	Boxes

TABLE 2-6

DIFFICULT-TO-SHRED ITEMS FOR THE HEIL HAMMERMILL

Sample	Date	Source	Component	Weight (lbs)	Size (inches)	Description
1.	2/22/84	Supply Center Building 19B	None	-		
2.	3/14/85	Building 1601 (Northside)	Steel Strapping	20	variable x 3/4" x 1/32"	Numerous 'pieces' of banding strap
3.	3/21/84	Building 228 CIA Area	None	-		
4.	5/16/84	Building 1603	Paper	60	12"x14"x16"	Full boxes of paper
5.	5/23/84	Building 67	Steel	8	4"D	Heavy terminal plugs
			Cardboard	400	24"x36"x18"	Shipping Boxes
			Steel Banding	29	1"x10"x1/16"	
			Paper	300	16"x12"x18"	10 boxes-unused forms
6.	5/30/84	Pier Q	Ceramic	60	30"x14"x16"	Toilet Base
			Rope	30	1/2"x100'	Bundles of Textile Rope
7.	7/11/84	Pier M	Wood	1000	min 2'x2'x1/4"	Pallets, crates, plywood
			Ferrous	20	24"x2"x1/4"	Angle Iron
			Nonferrous	12	20'x3/4"D	Roll of Coax wire
8.	7/25/85	Building 1502	Wood Boxes	125	1"x6"x6'	Lumber
			Cardboard	75	24"x24"x30"	Large Boxes
9.	8/15/84	Building 25	Wood	210	3'x3'	3 Hardwood Pallets
10.	8/22/84	Building 67	Cardboard	130	2'x3'x26"	Boxes
			Wood	70	1"x28"x36"	Pallet Portions

The Charleston County SWRC has a Cedarapids 5096 shear shredder, with a dedicated infeed and discharge conveyor, feeding one of two compactors. The second compactor is jointly fed by two Heil 42-F hammermills, which have separate infeed conveyors and a common discharge conveyor. Accurate records were maintained on the production of each compactor. Estimates were made concerning the amount of material processed by each of the hammermill shredders. Usually, the total production was divided evenly between the hammermills. When possible, data for both hammermills has been averaged to eliminate erroneous results caused by incorrectly estimated splits in production.

The results of the processing capacity measurements are shown in Table 2-7. Raw data is provided in Appendix E. The data in Table 2-7 does not include days when the equipment was down for repairs and production capacity was zero. The shear shredder processed over 48,000 tons and jointly the hammermills processed over 23,000 tons during the analysis period. Average, daily processing quantities were 295 tons for the shear shredder and 75 tons for each hammermill.

The average processing capacity for the shear shredder throughout an 8-month period, was 68.9 TPH during the time it was actually processing and dropped to 33 TPH as idle, blockage, repair, and no-fault hours were included. The average processing rate for the hammermills was 16.7 TPH, considering only active processing hours. This dropped to 8 TPH with the addition of idle, blockage, repair and no-fault hours. Averages of daily processing rates were similar to the overall 8-month weighted-average rates. Raw data for operating hours are presented in Appendix F. Daily shredder throughput rates are shown in Appendix G.

Although all shredders were processing MSW for nearly 700 hours over the 8-month period, the shear shredder displayed a capacity four times greater than that for each hammermill. As a result,

TABLE 2-7

PROCESSING CAPACITY OF SHREDDERS

	Shear Shredder	Vertical Hammermills		
	Mill #1	Mill #2	Mill #3	Combined
Days Tested	165	157	157	157
Tonnage	48,709	11,877	11,763	23,640
Daily Tonnage				
Average	295.21	75.65	74.92	150.57
Maximum	488.0	153.0	147.0	295.00
6-Month Operations Records				
a. Process Hours	706.6	732.7	683.6	1416.3
b. Idle Hours	530.2	277.7	313.8	591.5
c. Blockage Hours	10.5	11.2	27.3	38.5
d. Repair Hours	112.3	84.2	87.3	171.5
e. No-Fault Hours	113.1	369.9	363.7	733.6
6-Month Shredder Capacity, TPH				
a. w/a above	68.93	16.21	17.81	16.69
b. w/a and b	39.29	11.75	11.79	11.77
c. w/a, b and c	38.96	11.63	11.48	11.55
d. w/a, b, c and d	35.75	10.74	10.58	10.66
e. w/a, b, c, d and e	33.01	8.05	7.97	8.01
Average of Daily Capacities, TPH				
a. Process Hours, only	68.16	16.02	17.41	16.33
b. Process and Idle Hours, only	37.95	11.61	12.01	11.52
Peak Daily Capacity, TPH				
a. Process Hours, only	114.29	42.92	47.69	38.33
b. Process and Idle Hours, only	62.00	21.51	47.50	32.86

NOTE: All data were for an 8-month period.

the shear shredder processed four times the amount of material as each hammermill or two times the combined production of the two Heil 42-F shredders.

Characterization of Shredded MSW at the SWRC

Ten samples, each, of shear-shredded MSW and hammermill-shredded MSW were characterized between October 11, 1983, and July 20, 1984 for size distribution by compositional category. Individual data sheets are included for the shear shredder (Appendix H) and the hammermill shredder (Appendix I).

Composition of Waste. Average size data for the shear shredder are presented in Table 2-8. All sample data from Appendix H were averaged except for sample S-1 which had a glass content in excess of 40%. Average size data for the hammermill shredder are presented in Table 2-9. In this case, all the sample data from Appendix I were utilized except for Sample H-6 which had nearly 40% combined glass and inerts. Both of the above samples were excluded from the analyses, because each contained a total inerts content which appeared too high. However, the results presented are the averaged size and composition data from eight discharge samples from each shredder.

Comparing Tables 2-8 and 2-9, the discharge from the shear shredder had a much lower organic material content (73.42%) than the hammermill-shredded MSW (86.46%). The difference is made up predominantly by the shear shredded discharge having a higher glass (11.47% compared to 3.88%) and ferrous (6.62% compared to 3.71%) content. Additionally, the shear shredder discharge contained more nonferrous metals (2.66% compared to 0.96%) and inert material (5.83% compared to 4.99%) than the hammermilled MSW.

Table 2-8

SHEAR SHREDDER SIZE DISTRIBUTION -- AVERAGE DATA

	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
PAPER	0.00	0.13	0.89	7.83	6.71	2.83	0.99	0.23	0.04	0.00	19.65
PLASTIC	0.00	0.24	3.69	2.98	3.26	1.54	0.61	0.28	0.10	0.00	12.70
CARDBOARD	0.00	1.51	1.50	5.48	4.33	2.12	0.80	0.19	0.01	0.00	15.95
TEXTILES	0.00	0.83	0.47	1.09	1.30	0.46	0.23	0.07	0.00	0.00	4.44
WOOD	0.00	0.00	0.41	0.57	1.53	1.27	0.74	0.45	0.22	0.00	5.19
OTHER	0.00	0.00	0.18	0.62	0.83	1.81	2.57	2.20	1.76	5.51	15.49
TTL ORGANIC	0.00	2.71	7.13	18.57	17.97	10.03	5.95	3.41	2.14	5.51	73.42
GLASS	0.00	0.00	0.00	1.03	1.72	2.72	3.05	2.18	0.57	0.20	11.47
INERTS	0.00	0.00	0.00	0.00	0.57	0.64	0.77	0.66	0.98	2.20	5.83
TTL INERT	0.00	0.00	0.00	1.03	2.29	3.36	3.83	2.84	1.55	2.40	17.30
FERROUS	0.00	0.00	1.04	1.03	2.56	1.36	0.38	0.14	0.07	0.05	6.62
NONFERROUS	0.00	0.00	0.00	0.23	1.67	0.51	0.21	0.02	0.02	0.00	2.66
TTL METALS	0.00	0.00	1.04	1.26	4.23	1.87	0.59	0.17	0.09	0.05	9.28
TOTAL	0.00	2.71	8.17	20.86	24.49	15.26	10.36	6.42	3.78	7.96	100.00

TABLE 2-9

HAMMERMILL SIZE DISTRIBUTION - AVERAGE DATA

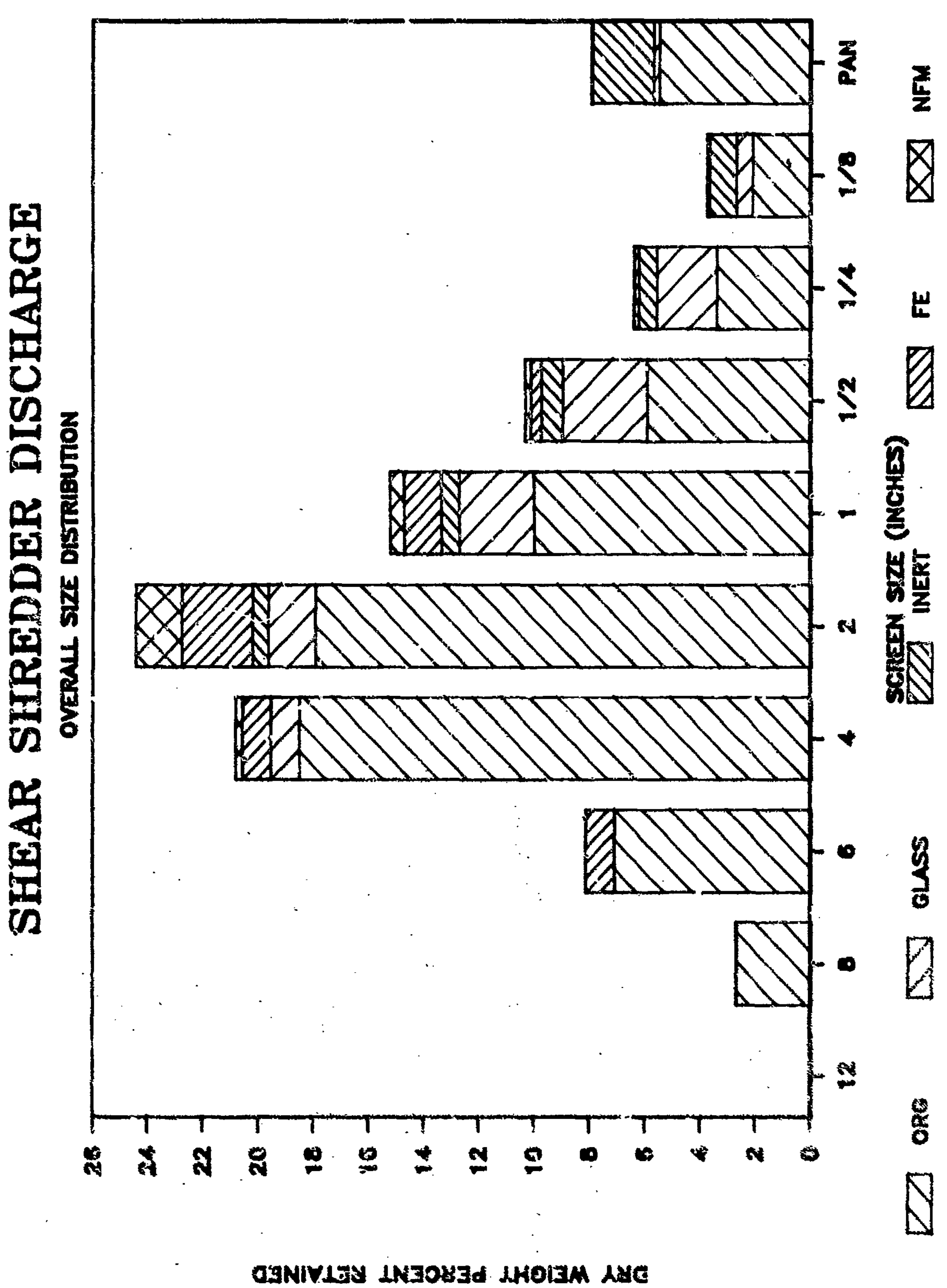
	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
PAPER	0.00	0.00	0.77	4.00	6.99	9.62	4.49	2.23	0.17	0.00	28.29
PLASTIC	0.53	1.05	1.34	3.38	2.60	2.05	1.96	0.88	0.19	0.00	13.98
CARDBOARD	0.00	0.25	1.20	6.57	5.81	4.83	2.06	0.52	0.22	0.00	21.47
TEXTILES	0.71	1.31	0.07	0.66	2.04	0.92	0.47	0.09	0.00	0.00	6.27
WOOD	0.00	0.00	0.00	0.40	0.62	0.41	0.56	0.20	0.00	0.00	2.20
OTHER	0.00	0.00	0.00	0.02	0.43	1.11	1.48	1.59	3.89	5.74	14.26
<u>TTL</u> <u>ORGANIC</u>	1.23	2.61	3.39	15.02	18.50	18.94	11.03	5.52	4.47	5.74	86.46
GLASS	0.00	0.00	0.00	0.00	0.02	0.47	1.26	1.81	0.22	0.10	3.88
INERTS	0.00	0.00	0.00	0.00	0.00	0.11	0.17	0.32	2.52	1.87	4.99
<u>TTL</u> <u>INERT</u>	0.00	0.00	0.00	0.00	0.02	0.58	1.43	2.13	2.74	1.97	8.87
FERROUS	0.00	0.00	0.00	0.53	1.94	0.63	0.34	0.18	0.04	0.04	3.71
NONFERROUS	0.00	0.00	0.00	0.15	0.45	0.18	0.12	0.05	0.01	0.00	0.96
<u>TTL</u> <u>METALS</u>	0.00	0.00	0.00	0.68	2.39	0.81	0.46	0.23	0.05	0.04	4.66
TOTAL	1.23	2.61	3.39	15.70	20.91	20.34	12.92	7.88	7.26	7.75	100.00

The low glass in the hammermill discharge may have been related to the fact that glass was pulverized and imbedded into the softer organic material by the high impact hammers. Alternately, it may have indicated the hammermill and shear shredders were fed different types of MSW. From the analyses on what Navy waste was considered unacceptable for each shredder, it appeared the Cedarapids 5096 had less constraints on the type of material that could be shredded. As stated previously, the shear shredder was believed to have difficulty shredding nylon webbing, steel steps, and aluminum blocks. In addition to the above items, the hammermill shredder was believed to have problems shredding all large material which could not fit into the feed chute including cardboard and wood, other flexible material such as textiles and cable which could wrap around the shaft, other tough material such as bundles of paper which would be rejected and explosive material.

The compositional content of the discharged MSW in each sieve size, is shown in Figure 2-1 for the shear shredder and Figure 2-2 for the hammermill shredder. Figures 2-1 and 2-2 show ferrous and nonferrous metals appear in the 1/4-inch to 4-inch size categories for both shredders. However, inerts appear in 6-inch size fraction and glass in the 4-inch size fraction for the shear shredder, while the same compositional categories are not present until the 1-inch size fraction for the hammermill-shredded MSW. This resulted because the shear shredder is low-speed and tended to break the brittle materials while the hammermill is high-speed and tended to pulverize the brittle fraction.

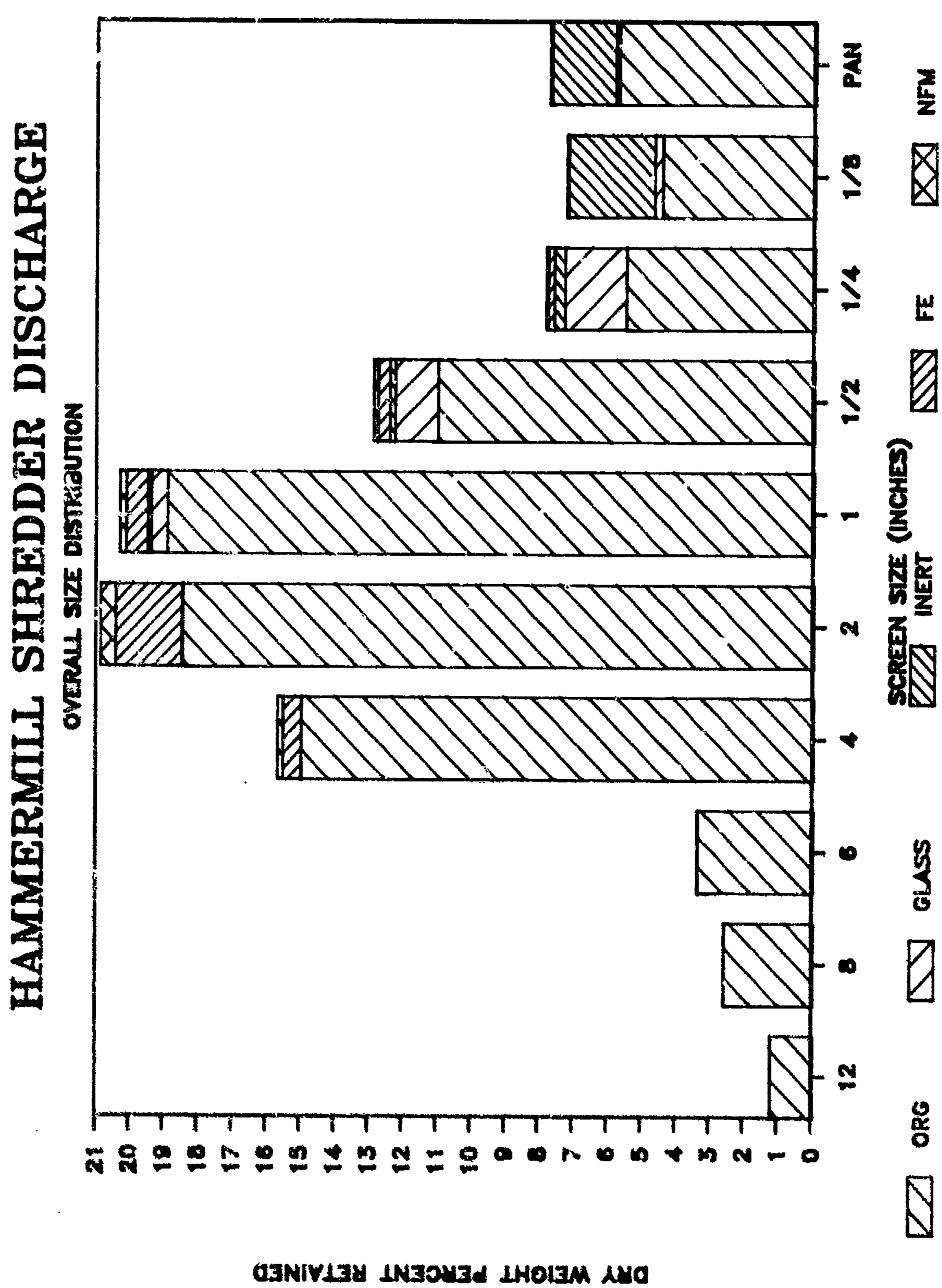
Size Distribution of Waste. The general shapes of both Figure 2-1 and 2-2 are shown in Figure 2-3. The curves are similar, except that the hammermill-shredded discharge curve is offset slightly to the right portion of the graph or to finer particle sizes. The size distribution of each compositional category from Figures 2-1 and 2-2 and for the total MSW are plotted in Figures 2-4 (shear shredder) and 2-5 (hammermill shredder), respectively,

Figure 2-1



SHEAR SHREDDER DISCHARGE
OVERALL SIZE DISTRIBUTION
DRY WEIGHT PERCENT RETAINED
0
2
4
6
8
10
12
14
16
18
20
22
24
26
SCREEN SIZE (INCHES)
12
8
6
4
2
1
1/2
1/4
1/8
PAN
ORG
GLASS
INERT
FE
NFM

Figure 2-2



HAMMERMILL SHREDDER DISCHARGE
OVERALL SIZE DISTRIBUTION
DRY WEIGHT PERCENT RETAINED
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
12 8 6 4 2 1 1/2 1/4 1/8 PAN
SCREEN SIZE (INCHES)
ORG
GLASS
INERT
FE
NFM

Figure 2-3

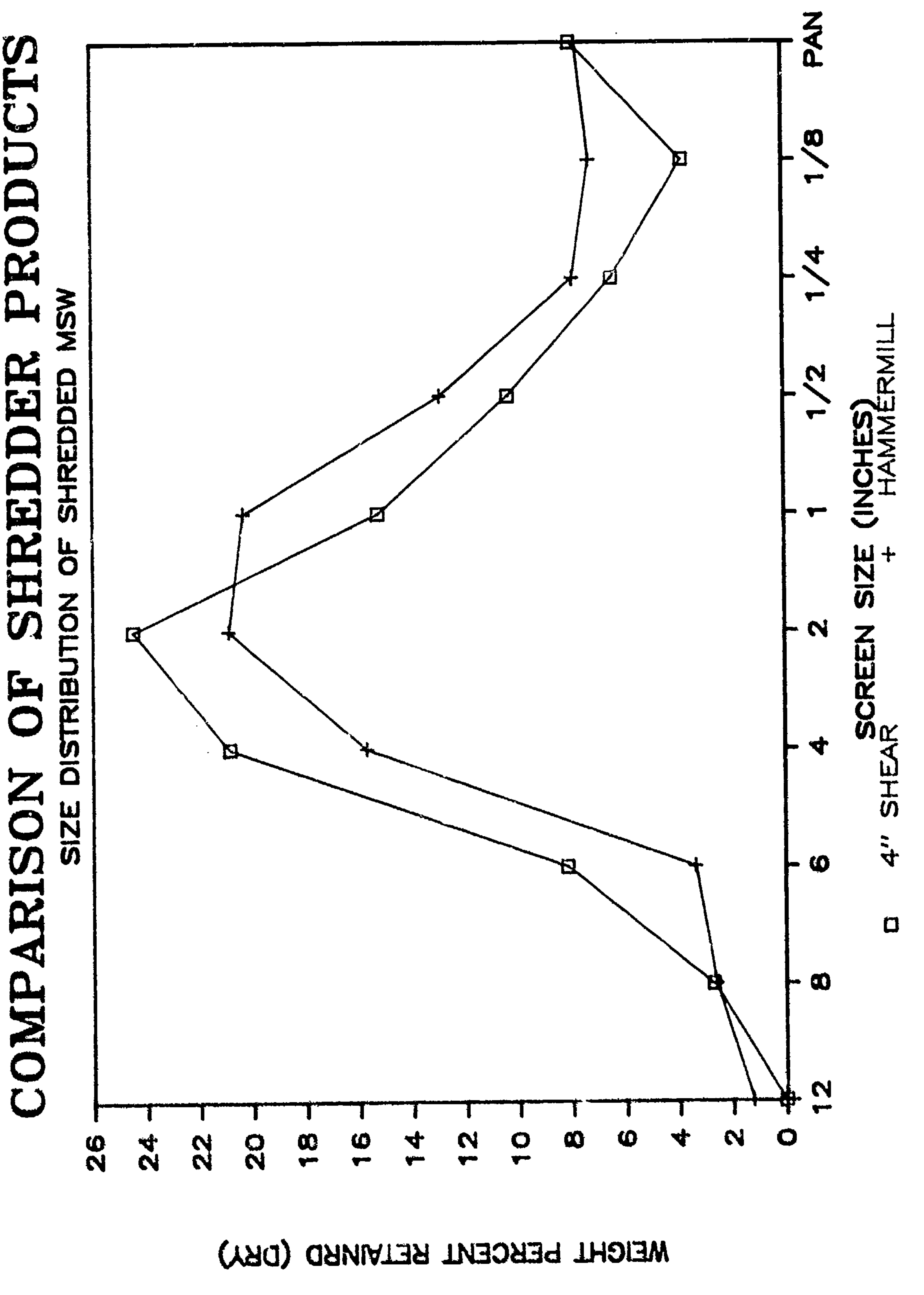

COMPARISON OF SHREDDER PRODUCTS
SIZE DISTRIBUTION OF SHREDDED MSW
WEIGHT PERCENT RETAINRD (DRY)
0 2 4 6 8 10 12 14 16 18 20 22 24 26
12 8 6 4 2 1 1/2 1/4 1/8 PAN
SCREEN SIZE (INCHES)
4'' SHEAR
HAMMERMILL

Figure 2-4

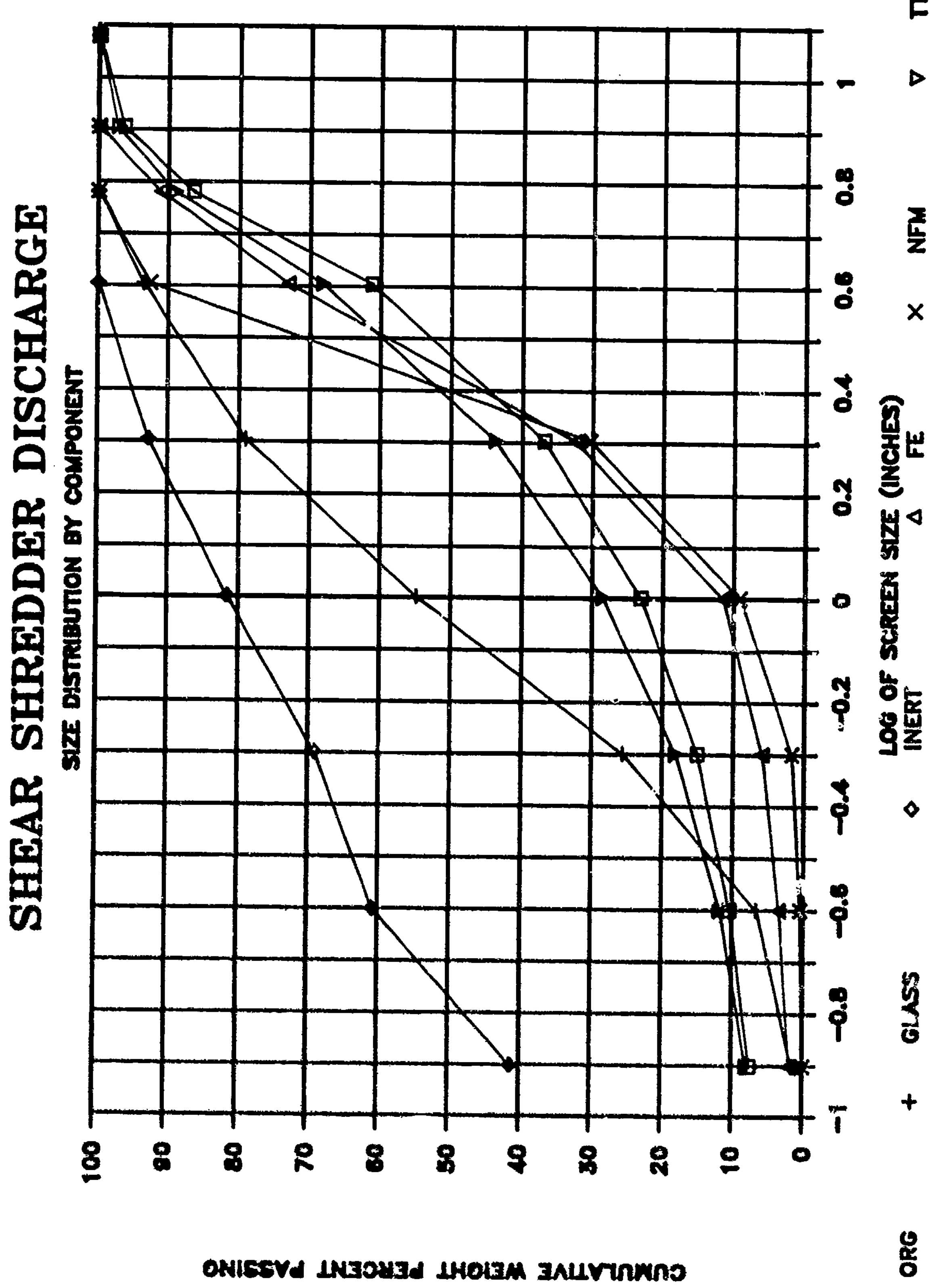
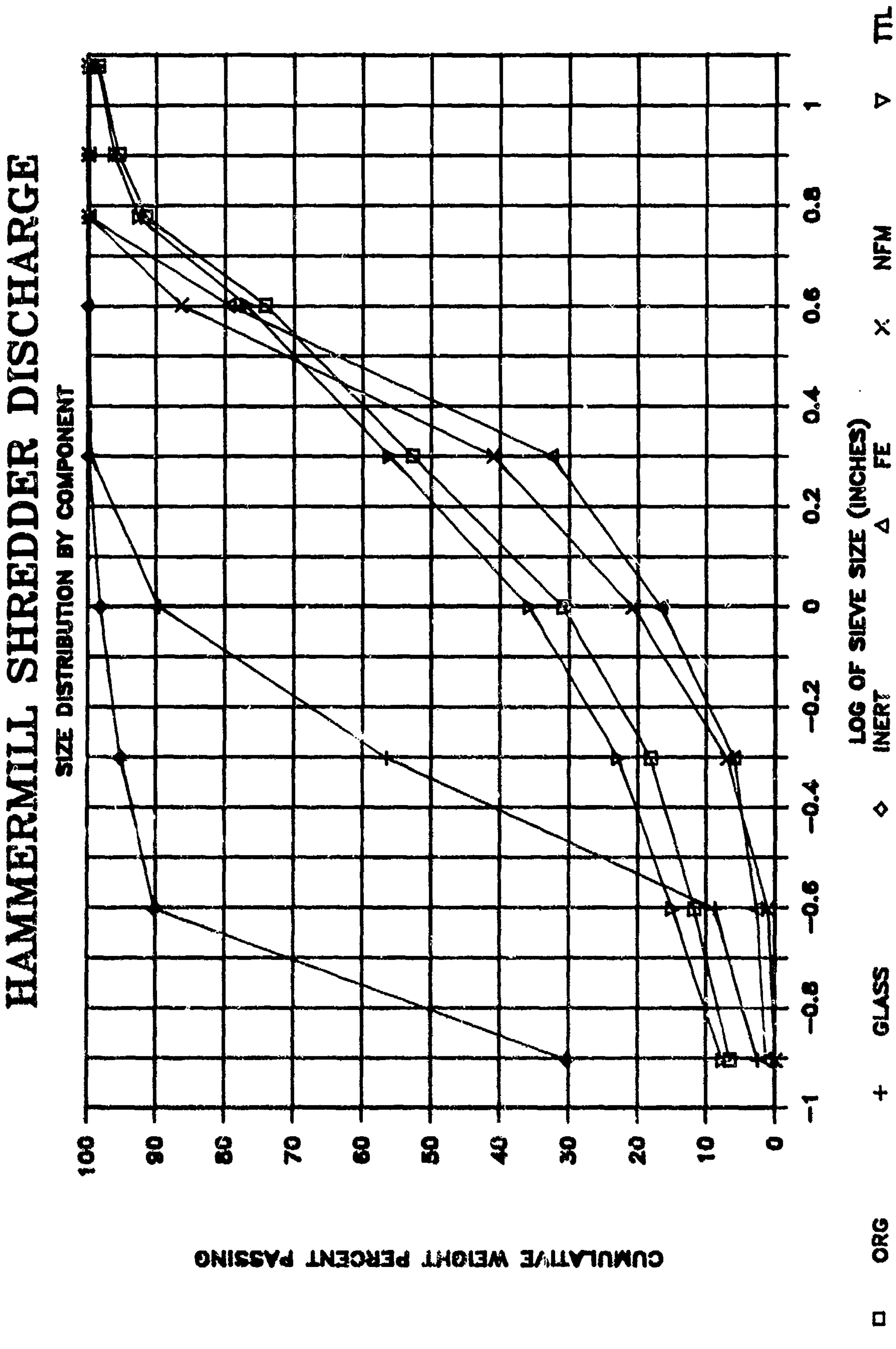

SHEAR SHREDDER DISCHARGE
SIZE DISTRIBUTION BY COMPONENT
CUMULATIVE WEIGHT PERCENT PASSING
LOG OF SCREEN SIZE (INCHES)
ORG
GLASS
INERT
FE
NFM
TTL

Figure 2-5



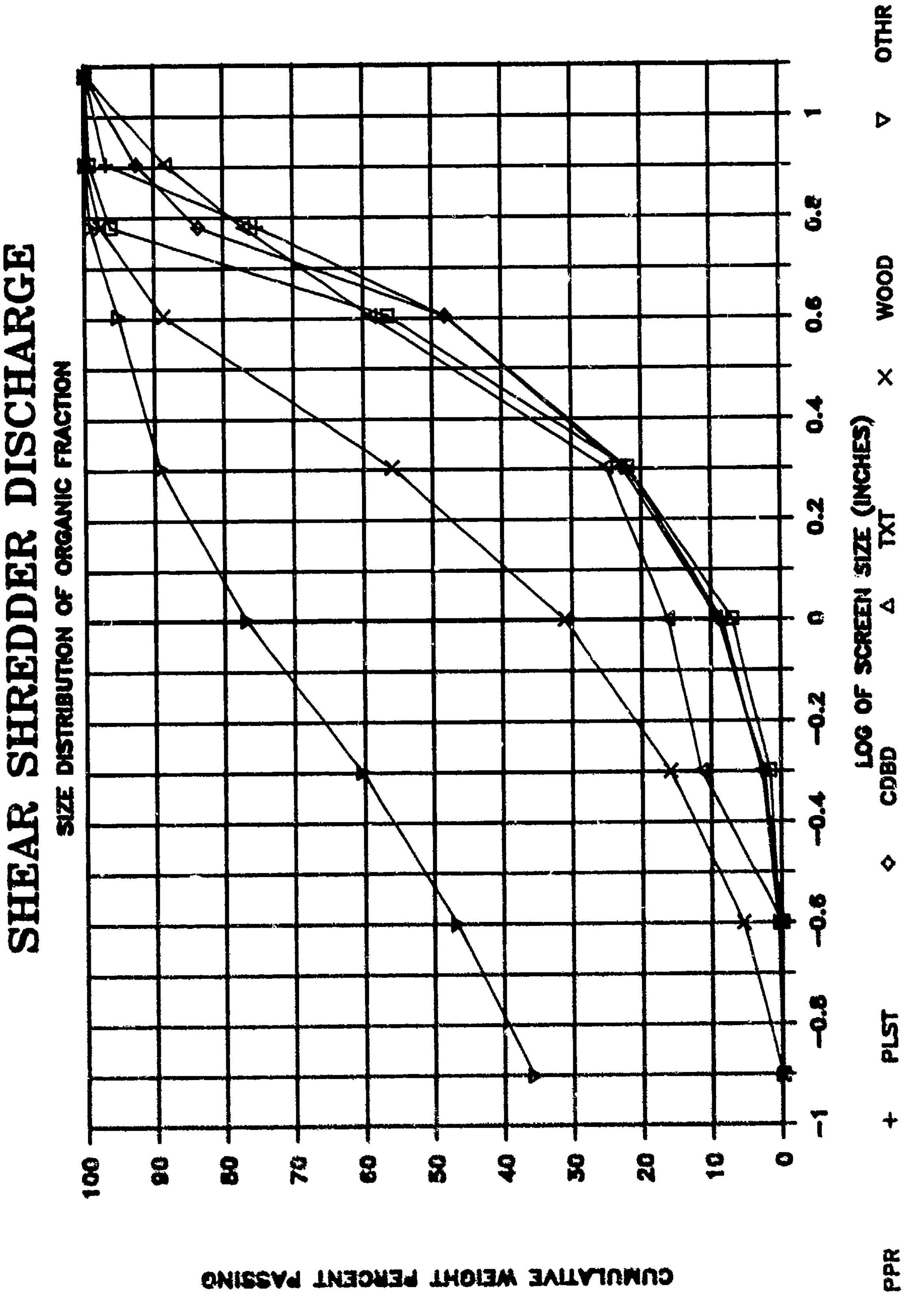
HAMMERMILL SHREDDER DISCHARGE
SIZE DISTRIBUTION BY COMPONENT
CUMULATIVE WEIGHT PERCENT PASSING
100
90
80
70
60
50
40
30
20
10
0
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1
LOG OF SIEVE SIZE (INCHES)
□ ORG
+ GLASS
◇ INERT
Δ FE
× NFM
∇ TTL

as the cumulative weight percent passing a sieve size, versus the base-10 logarithm of that sieve size. The curves are similar except for a slightly finer size distribution as noted for the hammermilled material. This is particularly noticeable in the relative positionings of the organics, the glass and the inerts curves. All these figures indicate that the hammermill produced a finer discharge particle size.

Similar cumulative percent passing versus logarithm of sieve size curves were drawn for the constituents of the organic fraction, Figures 2-6 and 2-7. Each figure shows six curves: paper, plastic, cardboard, textiles, wood and other organics. Figure 2-6 is of the shear-shredded discharge and Figure 2-7 of the hammermill-shredded discharge. The shear-shredded discharge appears slightly coarser in general and shows a more similarly-sized distribution for the paper, plastic, cardboard and textile fractions than for those displayed by the hammermilled discharge. For an alternative review of the same shear-shredded discharge data, Figure 2-4 and Figure 2-6 are replotted without the logarithmic scale as Figures H-1 and H-2 in Appendix H. Similarly, the hammermill-shredded discharge data, Figures 2-5 and 2-7, are replotted with the sieve size on a linear scale as Figures I-1 and I-2, respectively, in Appendix I.

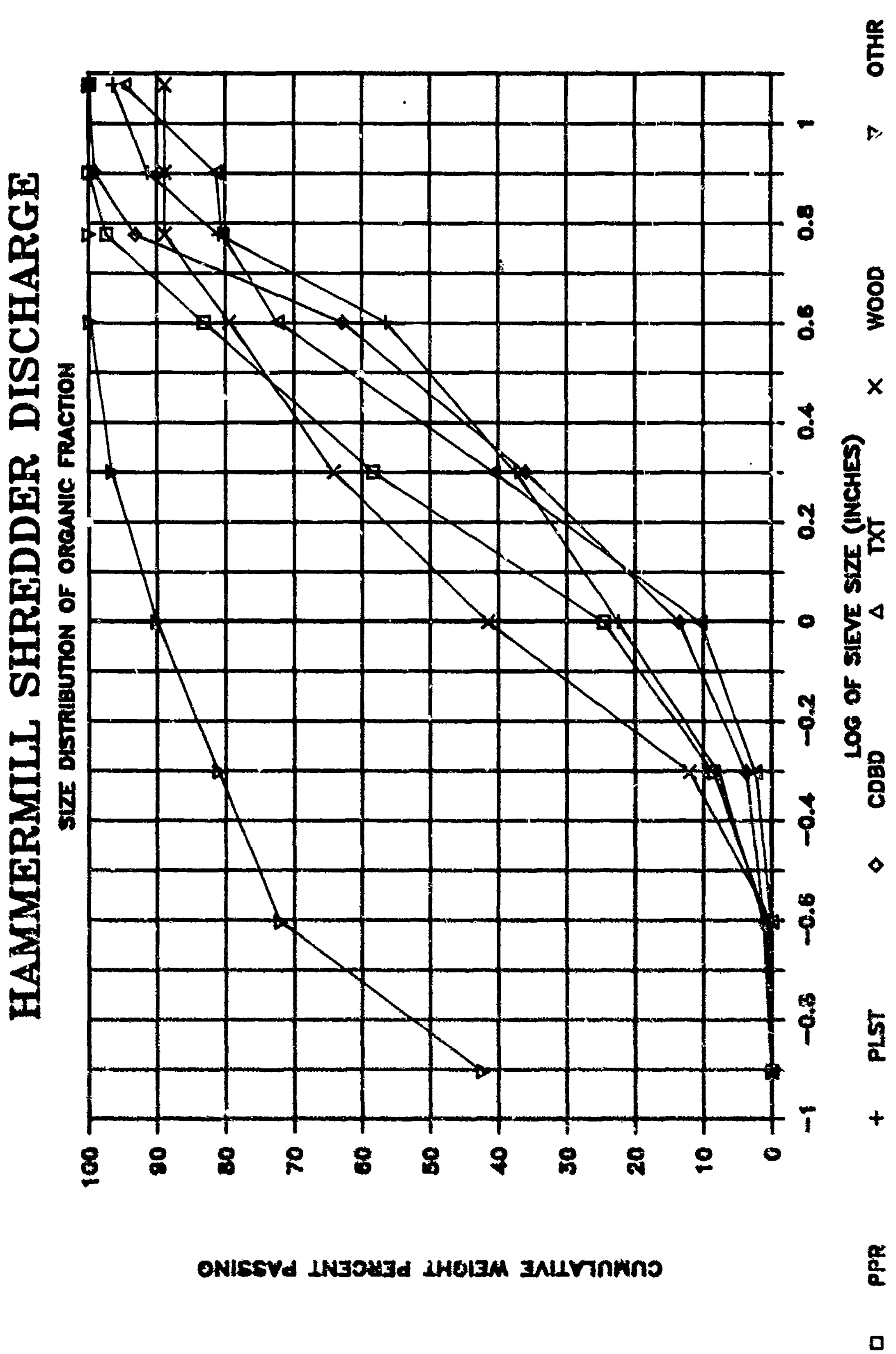
The graphs of the cumulative weight percent passing the sieve size versus the logarithm of the sieve size (Figures 2-4, 2-5, 2-6, and 2-7) are especially helpful in determining the nominal and characteristic particle sizes of the various solid waste constituents. The characteristic size, is the size of a hypothetical screen through which 63.2% of the material would pass and on which 36.8% would be retained. It provides a general size for the sample and is related to the Rosin-Rammler equation which has shown relatively good fit in describing shredded

Figure 2-6



SHEAR SHREDDER DISCHARGE
SIZE DISTRIBUTION OF ORGANIC FRACTION
CUMULATIVE WEIGHT PERCENT PASSING
100
90
80
70
60
50
40
30
20
10
0
LOG OF SCREEN SIZE (INCHES)
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
PPR
PLST
CDBD
TXT
WOOD
OTHR

Figure 2-7


HAMMERMILL SHREDDER DISCHARGE
SIZE DISTRIBUTION OF ORGANIC FRACTION
CUMULATIVE WEIGHT PERCENT PASSING
LOG OF SIEVE SIZE (INCHES)
PPR
PLST
CDBD
TXT
WOOD
OTHR

refuse. The nominal size is that size at which 90% of the material would pass and 10% would be retained. The nominal size is helpful from a materials handling/design basis in that it accounts for the coarser particle sizes.

Calculated characteristic and nominal particle size values are listed in Table 2-10. Those data clearly show the shear shredder produced a coarser particle size than the hammermill shredder. The ratic of total shear-shredded to total hammermill-shredded discharge-material for the characteristic sizes is 1.36, indicating the generally coarser particle size for the shear shredder. The ratio for the nominal size is only 1.11 which, being much closer to unity, suggests each shredder produces a similar amount of extremely coarse material.

The characteristic sizes of the other organics (4.1 inches compared to 2.8 inches) and glass (1.3 inches compared to 0.6 inches) fractions are especially coarser for the shear shredder. The nominal sizes of the glass and inerts are, also, particularly coarse for the shear shredder (by factors of 3.8 and 8.5, respectively), while the nominal size for the plastic, wood, and nonferrous metal fractions were greater for the hammermill discharge than for the shear shredder discharge. Here, the maximum size ratio was 1.5 (wood) favoring the hammermill-shredded discharge.

Power Consumption

Power consumption data for the shredders in Charleston, SC, are shown in Table 2-11. Power was reported for 105 days for the shear shredder and 99 days for the hammermill. Both the weighted average for the period and the average of daily data, show the shear shredder power consumption was slightly greater than 3.02 kwh/ton. For the Heil 42-F, the weighted average power consumption was 8.44 kwh/ton, which is two and one-half times greater than that for the shear shredder. The average of daily

Table 2-10

CHARACTERISTIC AND NOMINAL PARTICLE SIZE FOR SHREDDED MSW IN CHARLESTON, SC

	Characteristic Size (in)		Nominal Size (in)	
	Shear	Heil	Shear	Heil
Paper	4.2	2.3	5.6	4.9
Plastic	5.0	4.4	7.4	7.7
Cardboard	4.7	4.0	7.2	5.7
Textiles	5.0	3.2	11.5	10.4
Wood	2.2	1.9	4.1	6.3 (est)
Other Organics	0.5	0.2	1.9	1.0
TOTAL ORGANICS	**4.1**	**2.8**	**6.8**	**5.9**
Glass	1.3	0.6	3.8	1.0
Inerts	0.3	0.2	1.7	0.2
Ferrous Metal	3.5	3.1	6.5	4.9
Nonferrous Metal	2.9	2.8	3.9	4.5
TOTAL	**3.4**	**2.5**	**6.2**	**5.6**

Table 2-11

POWER CONSUMPTION BY SHREDDERS

	Shear Shredder Mill #1	Vertical Hammermill Mill #3
Days Recorded	105	99
Power Consumption, kwh for 5 months	100,000	66,400
Quantity Processed, tons for 5 months	33,098	7,866
Power to Quantity Ratio, kwh/ton for 5 months	3.02	8.44
Daily Power Consumption, kwh/ton		
Average	3.14	9.14
Maximum	6.90	36.36

power consumption values for the hammermill was 9.14 kwh/ton. This was slightly higher than the weighted average, most likely caused by daily, peak values which were as high as 36 kwh/ton. The maximum, daily, power consumed by the shear shredder was under 7 kwh/ton. Daily energy consumption data in units of kwh, are provided in Appendix E. Daily energy utilization data in units of kwh/ton, are presented in Appendix G.

Operations and Maintenance Experience

Operations and maintenance data were recorded for the Cedarapids 5096 shear shredder and each of the Heil 42-F vertical-shaft hammermills. An operating log was kept to record the hours during the shift that the shredder was running and the hours it was not running. The operating hours were divided into processing and idling hours. Downtime was split among blockage, repair, and no-fault hours.

Operating labor required for shredding, was classified as either operations, maintenance or management/other. Maintenance in this context referred to the routine maintenance that was required for each shredder. Major maintenance items were identified separately. Hours of downtime, man-hours for repair, and the cost of required parts were recorded for the major maintenance activities. This section first reviews the operating and downtime hours. It then presents the operations and maintenance man-hours and repair parts costs.

Operating Hours. A summary of 175 days of shredder operations is provided in Table 2-12. The summary lists the processing, idling, blockage, repair, and no-fault hours of each shredder from March 1 to September 20, 1984. Throughout this period, the shear shredder processed 38,634 tons, while the #2 and #3 Heil mills processed 9,351 and 9,262 tons, respectively. Daily operating and downtime data are presented in Appendix F.

Table 2-12

SUMMARY OF SHREDDER'S OPERATING LOGS

	Running Time		Downtime		
	Processing	Idle	Blockage	Repairs	No Fault
Shear Shredder, hours	706.6	533.2	10.5	112.3	113.1
Heil 42-F (#2), hours	732.7	277.7	11.2	84.2	369.9
Heil 42-F (#3), hours	683.6	313.8	27.3	87.3	363.7
Shear Shredder, %	47.88	36.13	0.71	7.61	7.66
Heil 42-F (#2), %	49.65	18.82	0.76	5.71	25.07
Heil 42-F (#3), %	46.32	21.26	1.85	5.92	24.65

Notes: 1. Results are the sums of 175 daily data points.

2. Total hours monitored per shredder, were 1475.7.

The total period for this analysis was 1475.7 hours. Each of the shredders during this period processed MSW for about 700 hours or just under 50% of the total operating shift. The shear shredder was allowed to idle without processing material for a greater portion of the time, 36% compared to approximately 20% for each Heil 42-F. The difference was almost totally counterbalanced by the no-fault hours, or those hours that the equipment was down, but operable. The shear shredder no-fault hours were less than 8% of the total time, while each hammermill had 25% of its time listed as no-fault hours. The Cedarapids 5096 shear shredder required approximately two percentage point greater time for repairs (7.6%) than the Heil 42-F's (5.7 and 5.9). Blockage time was close to 1% for all three shredders.

In the test period which was monitored, no hours were allocated to a sixth category in which the shredder is viewed as not operating, at fault for the lack of operation, but not in a repair mode. An example of this category would be the period of time resulting from the shredder experiencing a mechanical failure but not undergoing immediate repair due to the unavailability of repair parts. A second example would be a shredder explosion or fire which stopped operation, but required additional attention or remedial action prior to actually beginning shredder repair.

These data show the shredders experienced nearly identical operating histories. The major difference was that the shear shredder was often run without processing MSW, while the hammermills were normally turned off when not processing. The only real implication of this is that, compared to the hammermills, a greater percentage of the shear shredder power utilization was consumed during idle periods of operation. The shear shredder was not turned off as frequently as the hammermill because of its lower power requirements. In addition, the variety of feed material acceptable to the shear shredder was greater than the hammermills which resulted in the hammermills being turned off sooner and for longer periods than the shear shredder.

<u>Operating, Maintenance, and Management Labor.</u> Operations, maintenance, and management/other labor were tabulated for each shredder over a 7-month period beginning March 1 and ending September 20, 1984. Raw data are presented in Appendix E and summarized in Table 2-13.

Labor of an entire plant is difficult to allocate to specific unit operations. Usually, the work force is on the job regardless of whether the equipment is operating or not operating. In the case of the Charleston SWRC, County officials decided during normal operations the shear shredder required 12 man-hours of operating labor, 0.8 man-hours of routine maintenance labor, and 1 man-hour of supervisory labor. For the hammermills the labor breakdown was 11 man-hours for operating, 0.6 man-hours for maintaining and 1 man-hour for supervising each shredder. On Wednesdays, when less MSW was delivered to the SWRC, the operating man-hours were decreased to 8 for the shear shredder and 7 for each hammermill. No adjustments were made to maintenance and supervisory labor on Wednesdays. Only occasional reallocations were made for operational variations.

Data was recorded for 121 days of operation, as shown in Table 2-13. Operations labor was higher for the shear shredder (1360 man-hours) compared to each hammermill (1235 man-hours). Maintenance labor one third higher for the shear shredder (99 man-hours) than the hammermill (77 man-hours). Management labor was essentially identical for all shredders at 120 man-hours.

Table 2-13

OPERATIONS, MAINTENANCE AND MANAGEMENT
LABOR REQUIREMENTS FOR SHREDDING

	Shear Shredder	Vertical Hammermills		
	Mill #1	Mill #2	Mill #3	Combined
Days Recorded	121	121	121	121
Quantity Processed, Tons	38,634	9,351	9,262	18,613
Recorded labor, Man-hours				
Operations	1,359.5	1,232.3	1,236.8	2,469.1
Maintenance	99.4	77.4	76.4	153.8
Mgmt/Other	122.0	120.0	120.0	240.0
Calculated Labor, Man-hours/ton				
Operations	0.0352	0.1318	0.1335	0.1327
Maintenance	0.0026	0.0083	0.0082	0.0083
Mgmt/Other	0.0032	0.0128	0.0130	0.0129

However, since the shear shredder processed approximately four times the quantity of MSW as each hammermill shredder, the operations, maintenance, and management labor per ton of waste processed was much lower. These data are also presented in Table 2-13. The operating man-hours/ton were 0.0352 for the shear shredder and averaged 0.1327 for the hammermills. Similarly, maintenance labor was 0.0026 man-hour/ton for the shear shredder and 0.0083 man-hours/ton for the hammermills. Management labor was also less for the shear shredder than the hammermills, 0.0032 man-hours/ton compared to 0.0129 man-hours/ton.

Hence, in all labor categories, the shear shredder had higher, absolute labor requirements, but showed lower manpower utilization rates when viewed from the perspective of a unit ton processed. This was primarily due to the lower throughput rate capacities of the Heil 42-F's and the method utilized by Charleston County for labor allocation.

<u>Repair Hours, Man-hours, and Costs.</u> Major maintenance actions were considered repairs in this work. To be defined as a major maintenance action the remedy had to be non-routine, require at least one man-hour of labor, or have parts cost in excess of \$50.00. Examples of repairs for this study are the replacement of filters and cutters for the Cedarapids 5096 shear shredder and the replacement of hammers and liners for the Heil 42-F vertical-shaft hammermills.

Raw data for repairs is presented in Appendix J. The major requirement for the shear shredder was to replace cutters. Normally, this is anticipated at 20,000-ton intervals. However during the analysis period this activity occurred at approximately 15,000 ton intervals, had a cost of \$24,000 per set, and required 8 hours and 40 man-hours. A minor requirement was to replace filters for the hydraulic system. This appeared to occur at irregular intervals, depending on which of the four filters required replacement, but sometimes occurred in as little as 3,000-to-4,000 ton intervals. Filter replacement required very little labor, but cost $70 per filter. The Charleston County records listed the installation of new shafts and the replacement of a hydraulic motor on January 3 and February 3 of 1984, respectively. In both cases, the hours for repair were only listed. On March 5, a shaft collar required tightening. This was considered non-routine by the Charleston County records and included in repairs even though it required less than one hour and one man-hour.

Major repairs for the hammermills were the replacement of the mill liners in January, which cost $3,200, and the nearly weekly replacements of hammers. Each hammer cost $9, and from 6 to 18 hammers were replaced at a time. One-half hour and 1 man-hour of labor were required to replace six hammers. Hammer changes occurred in as frequent as 300-ton intervals. During the analysis period, mathematically, one hammer was replaced after every 35 tons processed in the hammermill. Again, the Charleston County records listed an explosion on February 23 and a fire on July 13. No allocation of man-hours or costs appeared to be tabulated with those occurrences.

Summary data on major maintenance/repairs are shown in Table 2-14. During the six-month period from January 1 to July 1, 1984, the shear shredder processed approximately four times the quantity of MSW as each hammermill (32,800 tons versus 8,100 tons). The hours required for repair of the shear shredder (40.7) was nearly double that for each hammermill (24). Man-hours required for repair were one-third higher for the shear shredder (91 compared to 66). The greatest difference was found in the repair parts cost. Repair parts for the shear shredder cost almost ten times as much as those for each hammermill, $49,500 for the shear shredder and $5,050 for each hammermill.

Table 2-14

SUMMARY OF REPAIR ACTIONS

	Shear Shredder	Vertical Hammermills		
	Mill #1	Mill #2	Mill #3	Combined
MSW Processed, Tons	32,681	8,138	8,049	16,187
Repair Time, hours	40.7	23.5	24.5	48
Repair Labor, man-hours	91	65.5	67.5	133
Repair Parts Cost, $	49,540	5,054	5,098	10,152
Repair Labor, Man-hours/ton	.0028	.0080	.0084	.0082
Repair Parts Cost, $/ton	1.51	0.62	0.63	0.63

Data from period January 1 - July 1, 1985

To compare the data, the man-hours and parts costs for repair were standardized to the unit quantity of waste processed. Labor for repair of the shear shredder was much lower than labor for each hammermill on a man-hour/ton basis. The shear shredder required one-third the labor (0.0028 man-hours/ton compared to 0.0082 man-hours/ton). However, in spite of the higher production, parts costs for the shear shredder remained higher than those for the Heil 42-F mills. Here, the shear shredder parts cost were $1.50/ton compared to $0.63/ton for the hammermills, a cost of 2 and 1/2 times greater.

Comparisons of Shredder Performance

A major demonstration program on shear shredders was funded by the New York State Energy Research and Development Authority at Chemung County, New York. That program included a comparative side-by-side study of a Cedarapids 5096 shear shredder and a Jeffrey 790 horizontal-shaft hammermill.

This section compares the performance of the Charleston County shredders to each other and to the Chemung County, NY, shredders.

Processing Capability of Charleston County Shredders. Data from Table 2-7 showed the shear shredder at Charleston County processed four times as much MSW (48,000 tons) as each hammermill (11,800 tons) during the January to September, eight month analysis period. Operating hours were nearly identical. Measured throughput rates showed the shear shredder processed at rates from three and one-half to four times that of each Heil 42-F hammermill. Peak rates were two and one-half times greater for the shear shredder. Manufacturers' data list the shear shredder and hammermill capacities at 35-60 TPH and 10-25 TPH, respectively. The average, measured capacities of the shredders excluding idle periods were 68 and 16 TPH, respectively. With idle included, the rates were still in the manufacturers' ranges at 38 TPH and 12 TPH. Therefore, each shredder processed according to its manufacturers' specifications during this study. The difference was that the shear shredder was designed for higher throughput rates.

The Cedarapids 5096 shear shredder produced a slightly coarser discharge-material particle size than the Heil 42-F horizontal hammermill. As shown in Table 2-10, both the characteristic size (3.4 inches) and the nominal size of the shear-shredded discharge (6.2 inches) were greater than the values for the Heil mill (2.5 inches and 5.6 inches). Although the discharge-material particle sizes were similar and the shear shredder processed more material at higher rates, power consumption by the shear shredder was less by a factor of three, 3.1 kwh/ton compared to 9.1 kwh/ton.

Performance-wise, the shear shredder appeared superior to the hammermill. It should be noted, the tonnages and throughput rate capacities of the hammermills were limited by the fact that they were not designed to provide better performance than that which was measured in this program. A larger vertical shaft hammermill would have greater capacities. However, higher horsepower motors would be necessary which may further widen the gap in power consumption.

<u>Comparison of Charleston to Chemung Shredders.</u> Comparative data for shredders in Chemung County, NY, are presented in Table 2-15. Chemung County has two shredders: a Cedarapids 5096 shear shredder and a Jeffrey 790 horizontal-shaft hammermill. At that facility, short-term demonstration testing funded by NYSERDA was

Table 2-15

COMPARISON OF SHREDDER PROCESSING INFORMATION

	Charleston County		Chemung County			
	4" Shear Shredder	Heil Vertical Hammermill	Cedarapids Shear Shredder			Jeffrey Horizontal Hammermill
	#1 Mill	#2 & #3 Mills	6"	4"	2"	
Quantity Processed (tons)	48,700	11,800	1,400	3,300	600	500
Capacity (tons/hour)						
Average w/idle	3[illegible].3	11.8	43.8	42.4	24.4	47.1
Average w/o idle	68.9	16.7	55.4	49.6	33.3	49.6
Peak w/o idle	114.3	38.3	93.9	90.3	41.1	67.8
Discharge Material Particle Size (inches)						
Characteristic Size	3.4	2.[illegible]	5.5	4.2	3.4	1.9
Nominal Size	6.2	5.6	14.3	7.2	5.7	5.6
Power Demand (kw)	-	-	118	120	123	90-240
Power Consumption (kwh/ton)	3.02	[illegible]	2.7	3.0	5.1	5.1

SOURCE: Charleston County data from January 1, 1984 - September 20, 1984
Chemung County data from NYSERDA Program, 1983

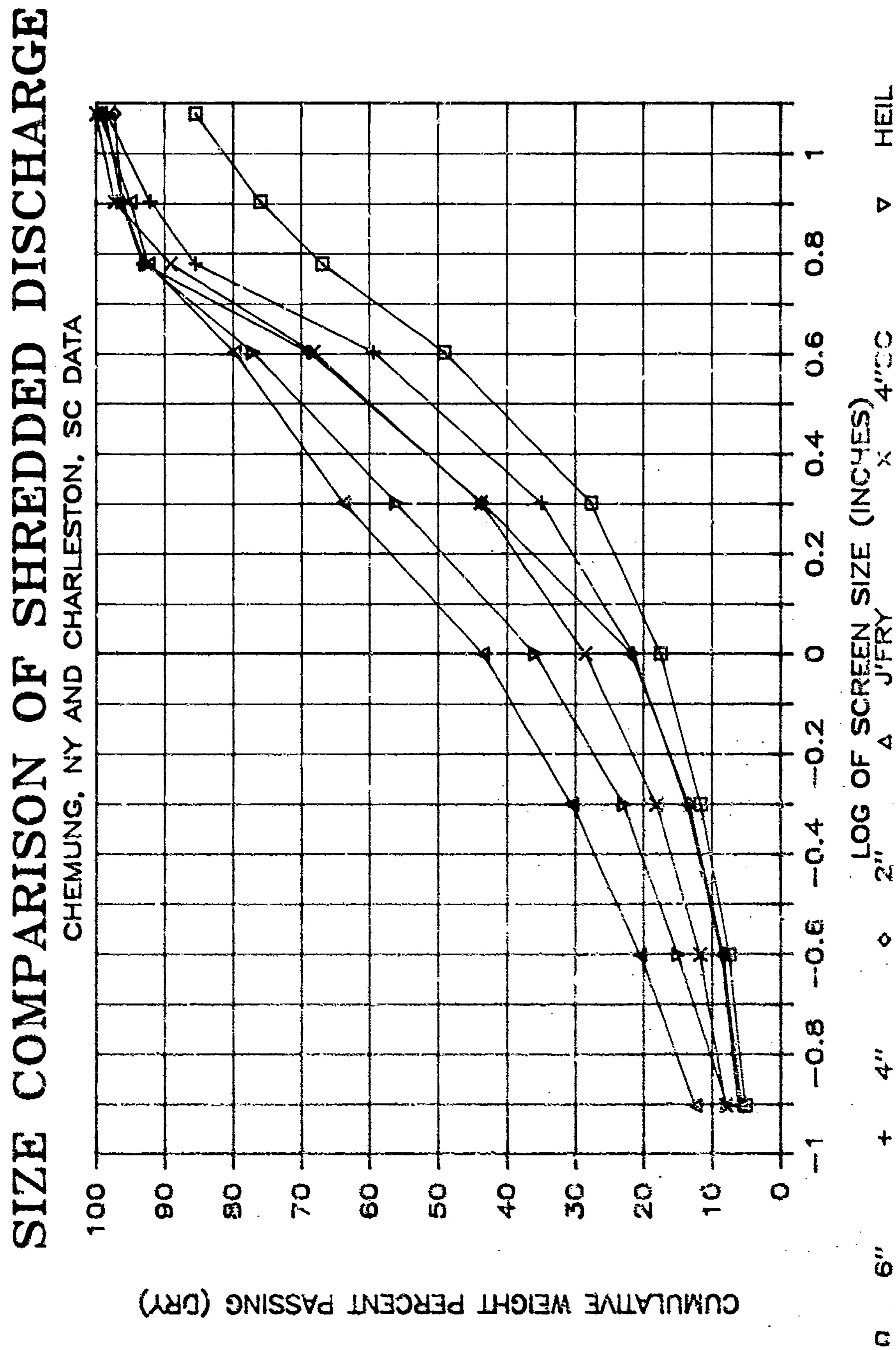
conducted on the shear shredder with 6-inch, 4-inch and 2-inch cutter patterns. The Chemung County data resulted from the averaging of individual transfer trailer loads, while the Charleston County data is the weighted average of daily production data.

The Chemung County data showed throughput capacity and particle size decreased and the power consumption increased, as the cutter width for the shear shredder decreased. None of the data for the shear shredder configurations matched exactly with the Jeffrey 790 data. The smallest shear shredder cutter width produced a discharge-material particle size and had power consumption which was similar to the Jeffrey shredder, but had lower throughput rates. The largest cutter width had comparable or superior throughput rates, clearly lower power consumption, but a coarser particle size.

Particle size distributions for the four shredder configurations in Chemung County and the two shredder configurations in Charleston County are shown in Figure 2-8. This shows the shear shredder with 4-inch cutters in Charleston County produced a particle size distribution which was finer than that produced in Chemung County with 4-inch cutters. In fact, the Charleston particle size distribution was much closer to the 2-inch shear-shredded discharge in Chemung County. Figure 2-8 also shows the Heil mill produced a finer particle size distribution than all the shredders tested except the Jeffrey 790 horizontal shaft hammermill.

Although further comparisons between the shredders and shredded discharge materials at the two sites can be made, there is the concern that different MSW compositions, operating procedures, and feed systems will have a large influence on the results. Nonetheless, the shear shredder at Charleston County processed at, generally, higher rates, with less power consumption, and

Figure 2-8


SIZE COMPARISON OF SHREDDED DISCHARGE
CHEMUNG, NY AND CHARLESTON, SC DATA
CUMULATIVE WEIGHT PERCENT PASSING (DRY)
LOG OF SCREEN SIZE (INCHES)
6"
4"
2"
J'FRY
4"CC
HEIL

produced a finer-sized discharge, than the Cedarapids 5096 shear shredder in Chemung County when installed with f... inch wide cutters. The better performance in Charleston is ...tributed to the fact that an apron conveyor is used to feed the mill, the mill has a sloped discharge chute, there is a better line of sight between the operating room and the shredder, and there is more operating experience. Chemung County utilizes a vibrating pan feeder, has a vertical feed chute, has a limited line of sight and has less experience. Also, the feed material may differ between the two sites. For example, Chemung County may have more commercial material.

Quality of Shredded MSW. Refuse-derived fuel was produced in the NYSERDA program from shear-shredded and hammermill-shredded Chemung County MSW. Approximately 25 tons, each, of 6-inch, 4-inch and 2-inch shear-shredded and hammermilled material were air-classified in the Monroe County Resource Recovery Facility (MCRRF) Cedarapids 11028 rotary drum air classifiers at approximately 60% of rated capacity. The hammermill utilized in that test was a Newell 1000 located at the MCRRF. The air classifier was utilized with identical settings to those which were used each day for the normal hammermill-shredding operation that was conducted at Monroe County. Refuse-derived fuels, recovered from those tests, were analyzed to determine the calorific value.

The results from the NYSERDA tests are shown in Table 2-16. Essentially, a higher quality fuel was recovered from the shear-shredded MSW, but a lower quantity was recovered. The high quality was attributed to the low glass and inerts content of the RDF. The MCRRF plant mass balance on glass and inerts is shown in Table 2-17. It showed 18% of the glass and 32% of the inerts

Table 2-16

AIR CLASSIFIED FUEL DATA

	Cedarapids 5096 Shear Shredder 152-mm 6-inch	102-mm 4-inch	51-mm 2-inch	Jeffrey Hmml
Light Fraction (% of Feed)	43.20	34.20	32.20	57.60
RDF (% of Feed)	39.38	30.67	29.71	54.51
ACLF Moisture (WT %)	25.15	19.10	32.44	28.73
RDF Moisture (WT %)	22.13	18.97	28.97	25.70
ACLF Ash (WT %)				
As Received	16. [illegible]	14.64	8.45	18.10
Dry	21.39	18.09	12.50	25.40
RDF Ash (WT %)				
As Recieved	8.15	11.76	9.24	14.75
Dry	10.47	14.52	13.01	19.85
ACLF Calorific Value (Btu/lb)				
As Received	5,537	6,181	5,949	5,099
Dry	7,398	7,640	8,806	7,155
Moisture/Ash-Free	9,411	9,327	13,034	9,591
RDF Calorific Value (Btu/lb)				
As Received	6,673	6,742	5,990	5,648
Dry	8,569	8,320	8,433	7,601
Moisture/Ash-Free	9,572	9,733	11,873	9,484

Source: NYSERDA work performed in Chemung County, NY

Table 2-17

GLASS AND INERTS DISTRIBUTION IN MCRRF PROCESS
VALUES GIVEN AS PERCENT OF FEED AND PERCENT OF SPECIES

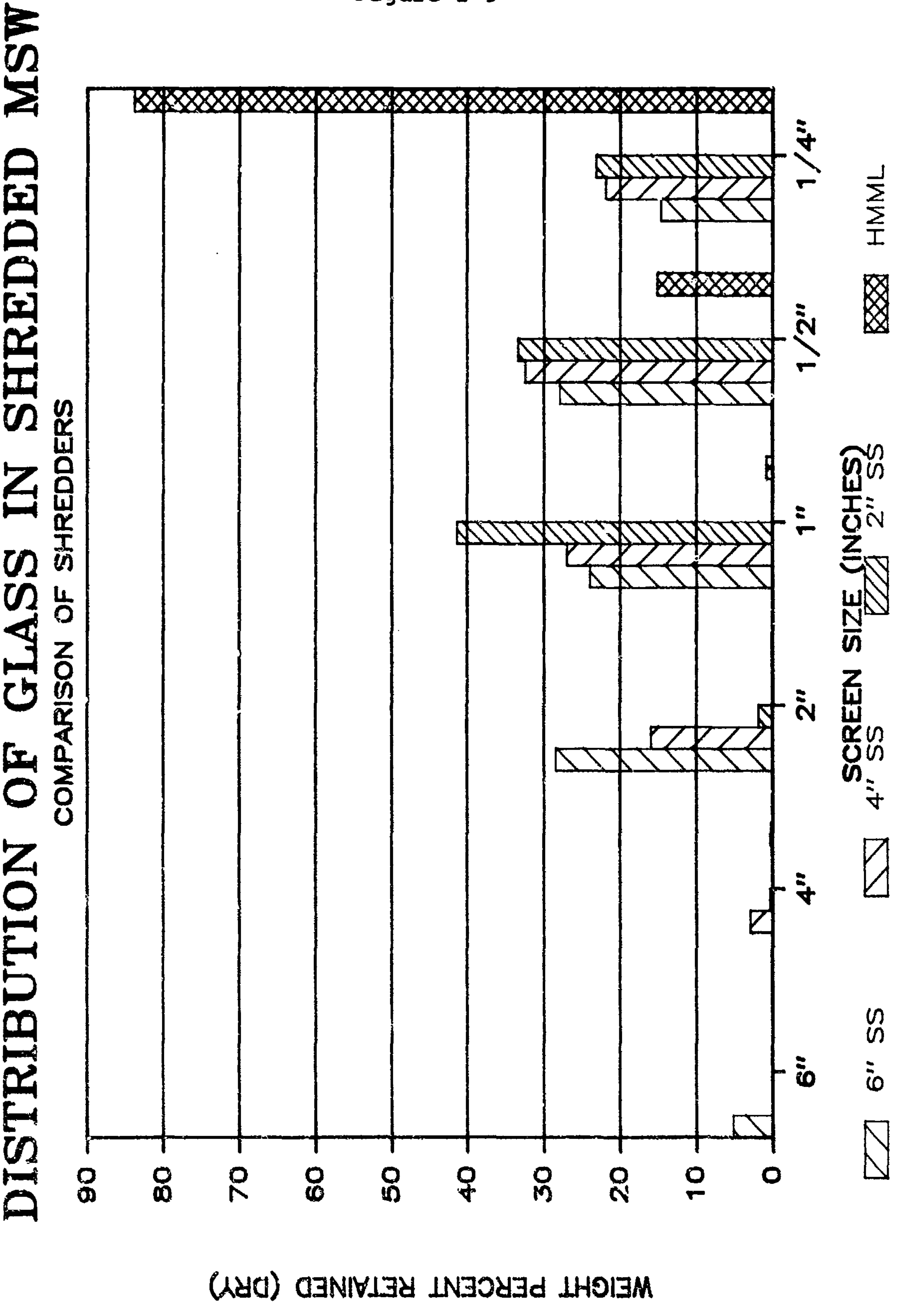
	RDF	Trommel O/S	Trommel U/S	Mixed FE	Screen 7 U/S	Total
Glass Distribution						
152-mm (6-inch)	0.20	1.27	3.47	0.00	0.19	5.13
	3.90	24.76	67.64	0.00	3.70	100.00
102-mm (4-inch)	0.12	2.20	7.54	0.00	0.09	9.95
	1.21	22.11	75.78	0.00	0.90	100.00
51-mm (2-inch)	0.24	3.46	6.83	0.01	0.23	10.77
	2.23	32.13	63.42	0.09	2.14	100.00
Hammermill	1.25	0.38	4.54	0.00	0.59	6.76
	18.49	5.62	67.16	0.00	8.73	100.00
Inerts Distribution						
152-mm (6-inch)	0.43	4.09	1.90	0.01	1.02	7.45
	5.77	54.90	25.50	0.13	13.69	100.00
102-mm (4-inch)	0.74	1.10	4.42	0.02	1.29	7.57
	9.78	14.53	58.39	0.26	17.04	100.00
51-mm (2-inch)	0.32	1.67	3.89	0.01	0.36	6.25
	5.12	26.72	62.24	0.16	5.76	100.00
Hammermill	1.42	0.75	1.87	0.01	0.34	4.39
	32.35	17.08	42.60	0.23	7.74	100.00

Source: NYSERDA work performed in Chemung County, NY that were in the infeed-MSW, reported to the RDF product when the MSW was hammermill-shredded. On the other hand, a maximum of only 3.9% of the glass and 9.8% of the inerts reported to the RDF product stream during the air classification of shear-shredded MSW's. It was believed the coarseness of the shear-shredded inorganics caused those materials to drop with the heavy product of the air classifier, thus improving the fuel quality. However, the coarseness of the heavier organic material caused that fraction to drop in the air classifier, subsequently decreasing the recovery. The large difference between the shear-shredded and hammermill-shredded discharges from Chemung County in size distribution of glass, can be seen in Figure 2-9. Some observers of the air classification tests believed that by modifying the air classifier variables, such as the drum inclination angle, a higher recovery of RDF could have occurred with shear-shredded MSW without a sacrifice in quality. Unfortunately, subsequent testing was not conducted.

Prior to the Navy program, it was expected the same logic would apply to the MSW shredded at Charleston County. However, the overall size distributions, Figure 2-8, showed the Charleston shear-shredded MSW was much more similar to the Heil hammermill-shredded MSW than the Chemung shear-shredded MSW was to the Jeffrey hammermill-shredded MSW. Utilizing the size distribution results from this program, it would be difficult to project the quality of the fuel which would result from air classifying the Charleston County shredded products.

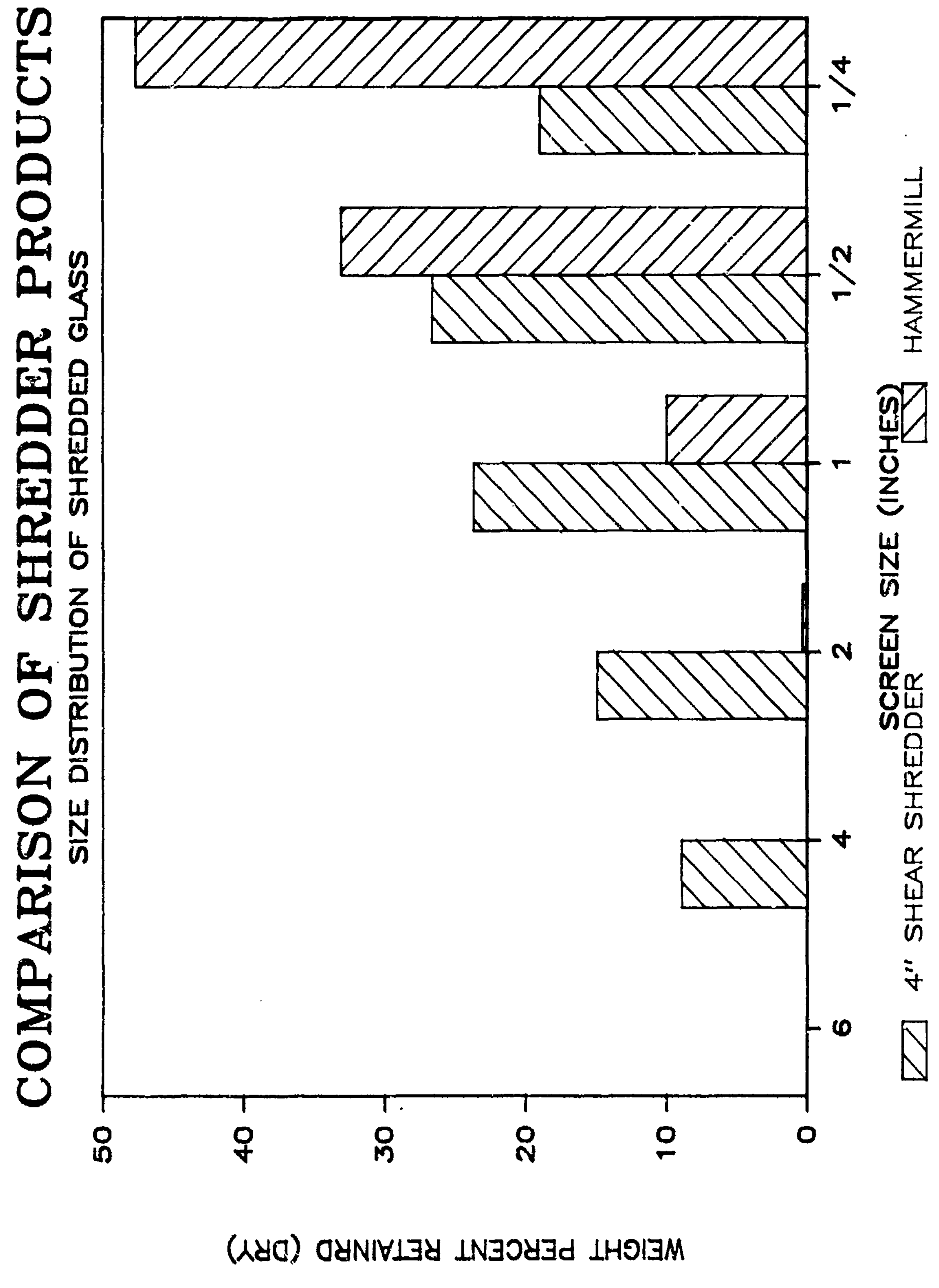
A closer inspection was made on the size distribution of the glass in the Charleston County shear-shredded and Heil hammermill-shredded MSW, Figure 2-10. As with the total MSW samples, the size distributions of glass were much closer to one another than those shown for the Chemung County results (Figure 2-9). Thus, projected differences in quality of the Charleston County MSW discharged from each shredder, viewed from the perspective of the ability to produce RDF, appear to be quite

Figure 2-9



DISTRIBUTION OF GLASS IN SHREDDED MSW
COMPARISON OF SHREDDERS
WEIGHT PERCENT RETAINED (DRY)
90
80
70
60
50
40
30
20
10
0
6"
4"
2"
1"
1/2"
1/4"
SCREEN SIZE (INCHES)
6" SS
4" SS
2" SS
HMML

Figure 2-10


COMPARISON OF SHREDDER PRODUCTS
SIZE DISTRIBUTION OF SHREDDED GLASS
WEIGHT PERCENT RETAINRD (DRY)
0
10
20
30
40
50
6
4
2
1
1/2
1/4
SCREEN SIZE (INCHES)
4" SHEAR SHREDDER
HAMMERMILL

limited from the data in this program. The glass content in the hammermilled MSW was only one-third that of the shear-shredded MSW which may have biased the results. It was also possible that glass was pulverized in the Heil hammermill and became embedded in the organic fraction.

<u>Operations and Maintenance Requirements of Shredders.</u> Comparisons of operating hours from Table 2-12 showed that all three Charleston County shredders operated for approximately 700 hours or nearly 48% of the shift. Although the shear shredders idled (actually operating, but not shredding) longer than the hammermills it had less no-fault (not operating, but capable of operating) hours. It was determined in Chemung County, when periods of idle time of 10 minutes or greater were anticipated for the shear shredder, it was economical from a power consumption point of view to turn the equipment off. Had this practice been followed in the Charleston County SWRC, the operations logs for the three shredders would have been virtually identical. Each of the shredders in Charleston County would have been processing, or able to process, on the order of 92% of the time. The remainder of the time would be ascribable to blockages and repairs. Downtime for repairs and blockages were almost identical for the shear shredder and vertical-shaft hammermills. This type of data was not developed during the short-term testing program in Chemung County and, therefore, no comparisons exist.

Operations, maintenance, and management/other labor were also nearly identical for the three mills. On a man-hour/ton processed basis, the shear shredder, due to its higher production, had much lower manpower requirements. All labor categories were one-quarter less. The advantage here, has to be placed with the shear shredder. It must again be stated, a higher capacity hammermill would compare much more favorably to the shear shredder on a man-hour per ton basis.

Officials at the Chemung County plant felt the maintenance labor requirements for the shear shredder were much lower than for the Jeffrey 790 hammermill, while operations and supervisory labor were considered equivalent. A detailed labor study is planned for the Chemung County shear shredder to determine the costs associated with the shear shredder. However, consequent to the shear shredder installation at Chemung County, the hammermill operations were ceased. Thus a comparative study of the two mills will not be conducted.

Repair Requirements of Shredders. The summary of repair actions for the Charleston shredders was shown in Table 2-14. From that summary, the shear shredder was shown to have a higher absolute requirement for repairs. Repair actions for the shear shredder were dominated by the cutter changes were required every 15,000 tons at a parts cost of $24,000. Hours, man-hours and repair parts costs for the Cedarapids 5096 shear shredder were higher than those for the Heil 42-F vertical hammermills by factors of 1.70, 1.37 and 9.77, respectively. Again, resulting from the higher production rates of the shear shredder, on a unit ton basis, those ratios were reduced to 0.42, 0.34 and 2.40.

This indicated the shear shredder required less hours and man-hours, but still had higher parts costs per ton of waste processed. With the above ratios, the higher cost of repair labor for the Heil 42-F is more than offset by the low cost of parts. Hence, the Heil mill would be favored from a repair parts point of view. Most of the items called repair parts in this study (cutters, filters, hammers, liners) would normally be considered as an operating cost element. Then the lower manpower and electrical costs of the shear shredder would both have a counterbalancing effect on the high parts cost. With this approach, both operating costs and repair parts costs for the two types of shredder would be very close.

Repairs in Chemung County were considered either scheduled or unscheduled maintenance actions. Parts costs for the shear shredder (i.e. cutters) were higher, but it was felt the low requirement for maintenance labor helped to offset that cost. The Jeffrey 790 hammermill required labor for the grates and hammers. In fact, hard-facing of the hammers was a major contributor to maintenance costs. Information was not available to calculate a man-hour per ton or parts cost per ton of waste processed for Chemung County. That is planned for a future NYSERDA study. It should be noted the identical type of cutters were used to shred 46,000 tons in Chemung County prior to replacement. This would substantially reduce the cost per ton processed which was calculated during the analysis period of this program utilizing a cutter life of 15,000 tons.

<u>Summary.</u> In general, most of the data produced in this program appears to favor the shear shredder. The only exception is the cost of repair parts (cutters versus hammers cost). There are two points to be made. The first is that shear shredders, applied to MSW shredding, are relatively new. As experience is gained, the cost of cutters per ton processed could be significantly reduced. The improvements could result from metallurgical changes in cutter alloys which extend cutter lives or improvements in manufacturing techniques which could significantly decrease the cost of cutters. The second point, is that a hammermill of comparable capacity to the shear shredder should be tested because most of the parameters from this study are dependent upon the throughput capacity of the mill tested. The rated capacity of the Heil 42-F was approximately three times less than the Cedarapids 5096 shredder. The Jeffrey 790 hammermill tested at Chemung County had a similar capacity, but a detailed analysis of that mill is no longer planned because operation of that mill has been curtailed.

RAM Analyses

Reliability, availability and maintainability (RAM) analyses were determined by Navy procedures (1) for the shear shredder and the vertical-shaft hammermill shredders from the data presented in Appendices E, F, G and J. When the data for the two Heil 42-F vertical shaft hammermills could be combined, they were. The period of analysis was January through June of 1984. Some of the RAM parameters have previously been calculated and presented in the initial portion of the Performance Evaluation section. However, the periods of analyses were not always identical to that of the RAM analyses. Thus, the RAM data will serve as a check on the other data and vice versa.

Eight discrete time periods were used to describe the operation of each shredder in the analyses. They were:

t_{a1}	=	Time shredder was energized and processing
t_{a2}	=	Time shredder was energized and idle (not processing)
t_b	=	Time spent in routine maintenance
t_c	=	Time spent in repairs/replacements
t_d	=	Time shredder was de-energized, but operational
t_e	=	Time shredder was de-energized, and not operational
t_m	=	Time over which uninterrupted operation was wanted for each shredder, or mission time
R_p	=	Active repair time spent on corrective maintenance

The time during which the shredders were energized, t_a, was broken into two categories -- t_{a1}, processing and t_{a2}, idling (not processing). This was done to distinguish the latter from t_d and t_e which are normally defined by the Navy as "idle (not energized) and operational" and "idle (not energized) and not operational", respectively. Also, dividing the operational time into processing and idling (not processing) format, better paralleled the Charleston County r records. This was also done to assess the sensitivity of the RAM parameters to the energized, idle time of the shredders. All RAM parameters used in this study, as well as other nomenclature, are presented in Appendix M.

The numerical values for the time periods, labor man-hours for each period, and other independent parameters during the January through June, 1984 period, are presented in Table 2-18. The results of the RAM analyses are presented in Table 2-19. Definitions and explanations of the acronyms and nomenclature are presented in Appendix M. The remainder of this section describes the RAM analyses results.

Reliability. Reliability data showed the vertical-shaft hammermills to be more reliable than the shear shredder. Mean Time Between Failures (MTBF) was 1413 hours for the hammermills and 422 hours for the the shear shredder. This was caused by the fact that the shear shredder had two failures (shaft replacement and hydraulic motor replacement) in the first month of the RAM analysis period. The Heil, #2 mill had only one failure (explosion) while the Heil, #3 mill had none during the January through June 1984, period. Thus the MTBF was undefined for the #3 mill. Expressed as a probability, R, the reliabilities were 0.99 for the hammermills and 0.98 for the shear shredder. Mission time was selected as 8-hours, or one operating shift.

From July to September the shear shredder had no additional failures. During that same period, both hammermills were shutdown due to a fire. Had the monitoring period been January through September 1984, the MTBF, including idle time as operating time, would have been 620 hours for the shear shredder and 1000 hours (averaged) for the hammermills. Expressing those

Table 2-18

VALUES OF PARAMETERS FOR RAM ANALYSES

Parameter	Shear Shredder Mill #1	Vertical-Shaft Hammermill Mill #2	Vertical-Shaft Hammermill Mill #3
Time, hours			
t_{a1}	484.2	524.1	497.3
t_{a2}	360.6	187.1	204.4
t_b	66.8	43.2	45.2
t_c	47.7	32.8	44.0
t_d	65.9	238.0	234.3
t_e	0	0	0
t_m	8	8	8
R_p	40.7	23.5	24.5
Labor, manhours			
M_{ta}	876.5	792.3	796.8
M_{tb}	62.2	49.5	48.5
M_{tc}	91.0	65.5	67.5
M_{td}	n.a.	n.a.	n.a.
M_{te}	0	0	0
Other			
Tons	32,861	8,138	8,049
N_f, No. of Failures	2	1	0
N_r, No. of Repairs	23	23	23
N_{ma}, No of Maint. Actions	95	95	95
CP, Cost of Parts	$49,540	$5,054	$5,090
CF, Cost of Fuel	3.14 kwh/ton at $0.06/kwh	-	9.14 kwh/ton at $0.06/kwh
CL, Cost of Labor	$6.00/hour		$6.00/hour
CC, Cost of Consumables	n.a.	n.a.	n.a.

Table 2-19

RAM ANALYSES RESULTS FOR CHARLESTON COUNTY SHREDDERS

Parameter	Status	Shear Shredder Mill #1	Vertical-Shaft Hammermill Mill #2	Mill #3	Combined
Reliability					
N_f		2	1	0	1
MTBF, hours	w/o idle	242.1	524.1	—	1021.4
	w/idle	422.4	711.2	—	1412.9
R (Let Tm=8)	w/o idle	0.97	0.98	—	0.99
	w/idle	0.98	0.99	—	0.99
Maintainability					
PMR, manhours/hour	w/o idle	0.1285	0.0944	0.0975	0.0959
	w/idle	0.0736	0.0696	0.0691	0.0694
CMR, manhours/hour	w/o idle	0.1879	0.1250	0.1357	0.1302
	w/idle	0.1077	0.0921	0.0962	0.0941
MI, manhours/hour	w/o idle	0.3164	0.2194	0.2333	0.2262
	w/idle	0.1813	0.1617	0.1653	0.1635
MTTR, hours		1.770	1.022	1.065	1.043
MTBMA, hours	w/o idle	5.097	5.517	5.235	5.376
	w/idle	8.893	7.486	7.386	7.436
Availability					
A_o	w/o idle	0.4723	0.5112	0.4851	0.4981
	w/idle	0.8240	0.6937	0.6845	0.6891
Long-Term Cost Effectiveness					
SOM, manhours/ton		0.0267	0.0974	0.0990	0.0982
SRM, manhours/ton		0.0047	0.0141	0.0144	0.0143
STM, manhours/ton		0.0313	0.1115	0.1134	0.1124
SPC, manhours/ton		$1.508	$0.621	$0.632	$0.627
SCC, manhours/ton		$0.189	$0.548	$0.548	$0.548
Average Cost, $/ton (=SPC+SCC+STM*CL)		$1.88	$1.84	$1.86	$1.85

reliabilities as a probability, R, would then result in values of 0.987 and 0.992 for the shear shredder and the average of the hammermill shredders, or a 0.5% variation between the values. Mission time was, again, selected as 8-hours.

<u>Maintainability.</u> With the idle period of the shredders included as operating time, the maintainability ratios for the shredders were similar with the hammermills requiring less labor for repairs, but the shear shredder requiring less time for repairs and less frequent repairs. The Preventive Maintenance Ratio (PMR), Corrective Maintenance Ratio (CMR), and Maintainability Index (MI) each favored the hammermill by a maximum of 1 man-minute of labor per hour of operations. PMR's were 0.0694 man-hours per hour for the hammermills and 0.0736 man-hours per hour for the shear shredder. CMR's were 0.0941 man-hours per hour (hammermill) and 0.1077 man-hours per hour (shear shredder). MI ratios were 0.1635 man-hours per hour (hammermill) and 0.1813 man-hours per hour (shear shredder).

The Mean Time to Repair (MTTR) favored the hammermill and the Mean Time Between Maintenance Actions (MTBMA) favored the shear shredder by 43.6 minutes and 87.4 minutes, respectively. This indicated the shear shredder, on the average, ran for an extra one and one-half hours before requiring maintenance, but required an additional three-quarters of an hour each time a repair was required. Calculated values of MTTR were 1.770 hours for the shear shredder and 1.043 hours for the hammermills. MTBMA ratios were 8.893 hours and 7.436 hours for the shear shredder and hammermill shredders, respectively.

All the maintainability indices were inferior to those stated when the idle period was not included in the analyses. The sensitivity of the parameters to idle time of the shredders can be seen in Table 2-19.

Availability. Operational availability (A_o) of each shredder was calculated with and without the idle (energized, but not processing) period. As stated previously, the shear shredder was allowed to idle for longer periods while the hammermills were turned off, and had higher no-fault times. As a result of this operational practice, the hammermills had higher (average) availability (49.8% compared to 47.2%) than the shear shredder without idle periods included and the shear shredder had higher availability (82.4% compared to 68.9%) with the idle time included. It should be noted, if no-fault hours were to be included in the definition, the availability would, again, favor the hammermills (91.9% compared to 88.8%). However, no-fault hours are not included in the Navy definition of operational availability.

Long-Term Cost Effectiveness. Long-term cost effectiveness was calculated for each shredder. Labor and utilities favored the shear shredder; repair parts costs favored the hammermills. Specific Operating Man-hours (SOM), Specific Repairs and Maintenance Man-hours (SRM) and Specific Total Man-hours (STM) were lower for the shear shredder by factors between 3.0 and 3.7 compared to the hammermill values. SOM ratios were 0.0267 man-hours per ton for the shear shredder and 0.0982 man-hours per ton for the hammermills. Calculated SRM values were 0.0047 man-hours per ton and 0.0143 man-hours per ton for the shear shredder and the hammermill shredder, respectively. Similarly STM for the shear shredder was 0.0313 man-hours per ton while that for the hammermill was 0.1124 man-hours per ton.

Specific Consumable Cost (SCC), which in this analysis was electrical power only, was 2.90 times lower for the shear shredder ($1.508 per ton) than for the hammermills ($0.627 per ton). However, the Specific Part Maintenance Cost (SPC) favored the hammermill ($0.627/ton compared to $1.508/ton) by a factor of 2.41.

As a result, the average cost per ton of waste processed at the Charleston County SWRC, calculated by adding the SPC, SCC, and the product of the STM and an average labor rate, favored the hammermill shredder ever so slightly, $1.85/ton versus $1.88/ton. An average labor rate of $6 per hour was assumed. If the average labor rate of $7 per hour was assumed, operation of the shear shredder would be less expensive than the hammermill, $1.92 per ton processed compared to $1.96 per ton.

<u>Summary of RAM Analyses.</u> During the January through June, 1984 analysis period, the RAM analyses appear to show a very minor difference between the hammermill shredder and the shear shredder. Based upon an operating shift as the mission time, reliability favored the hammermill by a difference in probability of about 0.01. Maintainability ratios showed the maintenance labor requirement per hour of operation, was approximately 10% higher for the shear shredder, while the mean time to repair were nearly identical and the mean time between maintenance actions favored the shear shredder by 19%.

The standard Navy definitions did not distinguish between "operating and not processing" and "operating and processing". This study did distinguish between the two. Utilizing the Navy definition of total operating time, the shear shredder operational availability was higher by 19.6%. Utilizing only the hours the shredders were operating and processing the hammermills showed an average operating availability 5.5% higher than the shear shredder.

Specific maintenance labor costs and electrical power costs were lower for the shear shredder. On the other hand, specific parts costs were higher. Calculated, average costs per ton for the shredding operations were very close -- $1.88/ton for the shear shredder and $1.85/ton, averaged for the hammermills. This cost included total labor, parts and electrical power costs. A labor cost of $6.00 per hour was assumed. If the labor cost increased beyond $6.44 per hour, the shear shredder had the lower cost.

Some of the RAM analyses parameters calculated in this section had lower values than those presented under the Equipment Performance section. For example, the sum of repairs and maintenance labor calculated in the Equipment Performance section were 0.0054 man-hours/ton for the shear shredder and 0.0165 man-hours/ton for the hammermill. RAM data SRM calculations showed results of 0.0047 man-hours/ton and 0.0143 man-hours/ton, respectively. Similarly, from the Equipment Performance data, the calculated sum of operations and management labor was 0.0384 man-hours/ton for the shear shredder and 0.1456 man-hours/ton for the hammermill. RAM data for SOM were 0.0267 man-hours/ton and 0.0982 man-hours/ton for the respective shredders. Parts costs for each respective shredder were the same in both the equipment performance analysis and the RAM analysis.

It is believed the differences were attributable to the total tonnages used to calculate the parameters. Periodically, information was missing from operating records. In the earlier section of Equipment Performance, those periods were avoided during calculation of the various results. For the RAM analyses, a constant period, January through June of 1984, was utilized. On occasion, periods of missing data were included in the RAM analyses. It should be noted, the ratios between the shear shredder and hammermill shredder data from the equipment performance results are nearly equivalent to those ratios from the RAM analyses results. This would indicate that whatever data was missing from the RAM analysis for one of the shredder's records were also missing from the other shredders' records. Cost analyses in the next two sections will utilize the higher of the man-hour per ton and dollars per ton values. Those were the data developed in the Equipment Performance section.

Section 3

LIFE-CYCLE COST ANALYSIS

Life-cycle cost comparisons were made of the two types of shredders at the Charleston County, SWRC. The analyses calculated the present value cost per ton of shredding for the Cedarapids 5096 shear shredder and the Heil 42-F vertical-shaft hammermill, at the measured, average throughput rate of the respective shredders at the SWRC. The present value cost shown in Table 3-1 was calculated both including facility capital investment and excluding capital investment (considering the capital cost as a sunk cost). The results of the analysis with the capital investment included, showed the cost per ton for shredding to be $2.34 for the shear shredder and $4.62 for the hammermill. With capital investment of the entire facility (including the building, auxiliary equipment, and shredder) excluded, the shear-shredding cost decreased to $1.60/ton while the hammermill decreased to $2.46/ton.

The latter approach was the preferred analysis, in that it appeared to more accurately model the status of the SWRC as of today. The hammermills were installed as original equipment in the SWRC while the shear shredder was retrofit at a later date, but prior to this program. This made cost comparisons more difficult, unless the capital cost for the entire facility was deleted. In addition, most published data on shredding costs are, predominantly, operations and maintenance costs which are comparable to considering the total capital cost as a sunk cost.

PROCEDURE

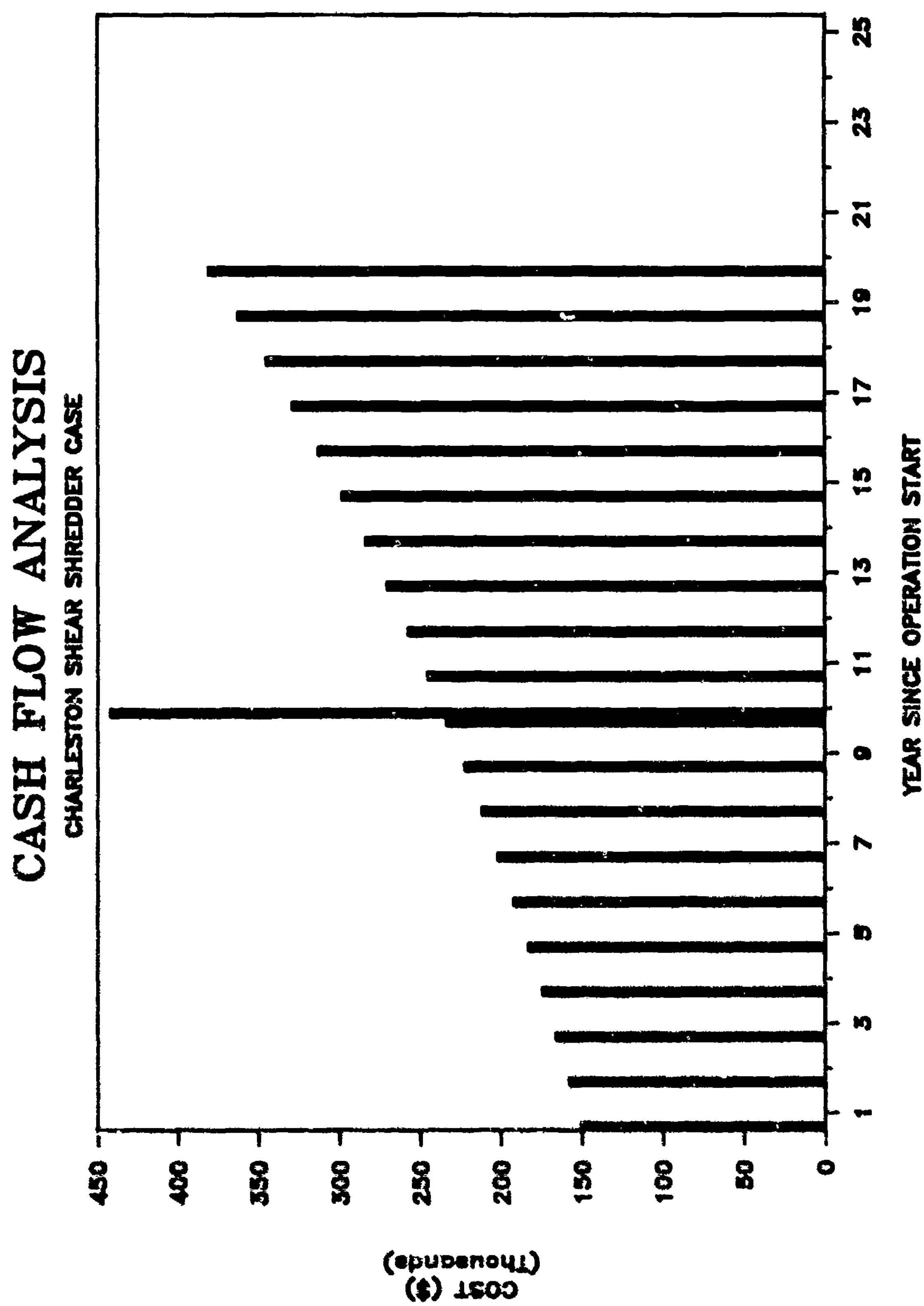
The analysis utilized the procedures (2) requested by the Navy. A cash flow diagram was developed for each shredder at the Charleston County SWRC. Figure 3-1 shows the cash flow diagram

Table 3-1

LIFE-CYCLE COST ANALYSIS FOR SHREDDING AT THE SWRC

	Shear Shredder	Hammermill
Expected Case (Capital Costs are Sunk Costs):		
PV of Original Capital Costs	0	0
PV of Major Equipment Replacement Cost	463,260	313,440
PV of Repair, O&M, and Disposal Costs	1,830,000	737,000
Subtotal Present Value Costs	2,293,260	1,050,440
PV of 20-year RDF Revenue	0	0
Net Present Value Cost	2,293,260	1,050,440
20-Year Production, tons	1,426,420	426,400
Net Present Value Cost per Ton	$1.60	$2.46
Alternative Case (Capital Costs are included):		
PV of Original Capital Costs	1,249,650	1,002,420
PV of Major Equipment Replacement Costs	283,658	108,666
PV of Repair, O&M, and Disposal Costs	1,660,000	670,000
Subtotal Present Value Costs	3,351,850	1,971,610
PV of 20-Year RDF Revenue	0	0
Net Present Value Cost	3,351,850	1,971,610
20-Year Production, Tons	1,426,420	426,400
Net Present Value Cost per Ton	$2.34	$4.62

Figure 3-1


CASH FLOW ANALYSIS
CHARLESTON SHEAR SHREDDER CASE
COST ($)
(Thousands)
0
50
100
150
200
250
300
350
400
450
YEAR SINCE OPERATION START
1
3
5
7
9
11
13
15
17
19
21
23
25

for the shear shredder, when the capital cost is excluded. A facility life of 25 years and shredder life of 10 years was selected from NAVFAC guidelines. Therefore, the project life for the life-cycle period was selected as 20 years, or two times the life of the shredder. An allowance was made at the tenth year to replace the shredder. It was anticipated the shredder would not be replaced in year 20 since the facility had only 5 years of service life remaining. Operations and maintenance costs were determined for every year of the 20 year project life using an inflation rate of 5%.

When capital investments were included in the cost analysis, a construction period of one year was selected and the capital costs were paid quarterly. The time value of money of construction payments was incorporated into the analyses at an annual rate of 10%. The present value of all costs for each year of the 20-year life were then calculated for the base year, in this case 1985. The ability to generate an RDF revenue was included in the analysis for each year of the 20-year project life. A 1985 present value for revenue was also calculated. Finally, the net present value (cost minus revenues) was calculated and divided by the total production for the 20-year period to arrive at a net present value cost-per-ton calculation.

COST ESTIMATES

Information for the life-cycle cost analyses utilized measured data from this program, to the maximum extent possible, other published data when available, and estimates when required. The data which was used for both the shear shredder and the hammermill analyses are presented in Table 3-1. All costs were determined in 1985 dollars and inflated at 5% annually for subsequent years.

Operations and Maintenance Costs

Labor rates for solid waste facilities in the general Charleston, SC, area were reviewed. Three categories of labor were used: operations - $7.50/hour, maintenance - $5.25/hour, and administrative - $10.50/hour. A burdening factor of 1.25 was applied to each rate to cover fringe benefits. Man-hour per ton labor data, developed in this program, were used in the analyses.

Consumables' costs for the Charleston shredding operation were dominated by electrical power costs for both shredders and blade and hammer changes for the shear shredder and hammermill, respectively. The electrical power cost in the Charleston area is approximately $0.06/kwh. Power consumption data, measured in this program for each shredder, were used. Cutter blades cost $24,000 per set for the shear shredder and hammers cost $9.00 apiece for the vertical-shaft mills. The repair parts cost-per-ton, calculated in this program for each shredder, was employed in the life-cycle cost analyses.

Disposal costs for Charleston County are approximately $8.60/ton, however, a value of $1.00/ton was utilized in this particular analysis. This lower value was used because, in this case, the cost refers to a differential disposal cost which occurred for shredded versus unshredded MSW being sent to the landfill. In Charleston County, both shredded and unshredded solid waste is landfilled. However, unshredded waste requires more landfill volume and more cover material. This has been estimated as having a cost impact of $1.00/ton on the unprocessed waste. In that all the material is landfilled, there was a $0.00/ton value assigned to the fuel produced. Availability of the shredders, as determined in this contract, were applied to annual shredder production figures. This was accomplished by utilizing shredder throughput rates, as determined when process, idle, blockage and repair hours were included in the calculation. Thus, processing rates employed in the cost analyses were 35.75 TPH and 10.66 TPH, for the shear shredder and hammermill shredder, respectively.

Capital Costs

It should be recalled, the preferred analyses did not include capital costs and considered the cost of the facility as a sunk cost. In that case, all capital costs added to zero. In the case when capital cost is included, the capital cost consisted of construction costs and financing costs. The costs are itemized for each shredder in Appendix K. Construction costs included the facility -- foundation, structural supports, access, electrical equipment, processing equipment, spare parts, and so forth which totaled $607,440 for the shear shredder and $412,500 for the hammermill; installation costs which totaled $217,840 for the shear shredder and $249,520 for the hammermill; engineering and construction management costs at 12% of the installation costs; and a management reserve at 15% of the installation costs. Financing costs for each shredder were calculated as 25% of the sum of the facility, installation, engineering/construction supervision, and management reserve costs. The equipment cost in 1985 dollars was also inflated to 1995 dollars at 5% to determine the equipment replacement cost in year 10. The present value of that cost was calculated for year zero.

Capital costs for the shredders were estimated at $300,000 for the shear shredder and $87,000 for the hammermill. The ratios of the total equipment and material costs to the shredder costs were 2.02 for the shear shredder and 4.74 for the hammermill. If infeed and discharge conveyors were in existence and conveyor costs (estimated at $214,000 in both cases) were excluded from the facility equipment costs, then the ratios of the total equipment and materials costs to the shredder costs would decrease to 1.31 for the shear shredder and 2.28 for the hammermill. The extremely low ratio for the shear shredder has been calculated (4) and supported by manufacturers (5,6). The manufacturers indicated in the more complex installations, a factor of 25% to 30% above the cost of the shear shredder is a cost estimate which should safely cover the ancillary equipment. For simple installations with existing conveyors, the cost ratios can be much lower. Typically, the shear shredder price includes a stand, feed hopper, and local control panel and the only additional material costs are for transition chutes, anchor bolts, grouting, electrical connections and control wiring.

Capital cost data is referenced in Appendix K with the source of the information. Sources include Chemical Engineering Magazine, Means, a Charleston County Shredder Explosion Insurance Claim Report, Allen Bradley Catalogue data, actual data, calculated data from this contract, and engineering estimates.

DISCUSSION OF RESULTS

The life-cycle analyses results for shredding at the SWRC are shown in Table 3-1. For the preferred case (without capital costs and first day of operations is day zero), the present value of the major equipment (shredder) replacement favored the hammermill by a ratio of 1.48 costing $463,260 for the shear shredder compared to $313,440 for the hammermill. Also, the present value of operations and maintenance costs favored the hammermill by a ratio of 2.48. The shear shredder cost $1.83M to operate; the hammermill $737K. However, the shear shredder processed 1.426M tons of solid waste while the hammermill could only process 426,400 tons over the 20 year period. Hence, the cost per ton was $1.60 for the shear shredder and $2.46 for the hammermill.

The same was found when the initial capital was included and the first day of construction was day zero, or the reference day. The project life became 21 years, but only 20 years were processing years. The other year was the construction period. With this small variation, the present value equipment costs and operations and maintenance costs were slightly less than those for the previous case, but the ratios were identical. Major equipment costs were $442,200 (shear shredder) and $299,190 (hammermill), again, favoring the hammermill by a factor of 1.48. Total present value of operations and maintenance costs were $1.66M (shear shredder) and $670K (hammermill), a ratio of 2.48. In this case, capital for the shear shredder was $1.25M and that for the hammermill was $1.00M or 1.25 times less. Once again, the 20-year production capacity of the shear shredder was over three times that of the hammermill. The calculated net present value for the shear shredder on a per-ton-processed basis was lower, $2.34 compared to $4.62.

The life cycle cost analyses for the Charleston County SWRC parallel those findings in the Equipment Performance section. The overall cost of operating the shear shredder is higher, but the production is higher. On a cost per unit-ton processed basis, the shear shredder cost is lower.

Section 4

PROJECTED LIFE-CYCLE COST ANALYSIS

The life-cycle cost of a 50-TPD Navy shredding facility was determined. It was assumed the shredding station could be located next to an existing heat recovery facility which had a front-end loader. The Navy shredding station was also expected to be new, and, thus, would require construction. As shown in Table 4-1, with those assumptions, the net present value cost per ton of solid waste shredded, was $4.27 for the shear shredder and $4.36 for the hammermill. If either of the shredders were previously installed in an existing facility, capital costs could be eliminated and the net present value would drop. Then, it would cost $1.12 per ton for processing with the hammermill. In the case of the shear shredder, the cost would be reduced to $0.44 per ton.

Some of the previous work under this contract indicated the shear shredder offered advantages over the hammermill. Electrical power consumption and labor were lower per ton processed, than for the hammermill. Parts costs were higher than those for the hammermill, but appeared to be more than offset by the low power and labor requirements. More types of material and more material could be shredded in the shear shredder. The mean time between maintenance actions was longer and there were no explosions and fires. The hammermill shredder was favored in other areas. As stated, repair parts costs were lower. Also, the mean time to repair the hammermill shredder was less than that for the shear shredder. Labor for the hammermill was lower on a per hour basis.

Availability and discharge material particle size results were less clear. The availability of the shear shredder was much higher than that of the hammermill shredder when idle was

Table 4-1

LIFE-CYCLE COST ANALYSIS FOR 50-TPD NAVY SHREDDING STATION

	Shear Shredder	Hammermill
Expected Case (Capital Costs are Included):		
PV of Original Capital Costs	1,142,100	98[illegible]
PV of Major Equipment Replacement Cost	367,710	26[illegible],000
PV of Repair, O&M, and Disposal Costs	517,000	[illegible]83,000
Subtotal Present Value Costs	2,026,810	1[illegible]940,620
PV of 20-year RDF Revenue	746,880	634,030
Net Present Value Cost	1,279,930	1,306,590
20-Year Production, tons	300,000	300,000
Net Present Value Cost per Ton	$4.27	$4.36
Alternative Case (Capital Costs Sunk Costs):		
PV of Original Capital Costs	0	0
PV of Major Equipment Replacement Costs	385,220	280,760
PV of Repair, O&M, and Disposal Costs	569,000	752,000
Subtotal Present Value Costs	954,220	1,032,760
PV of 20-Year RDF Revenue	822,000	697,000
Net Present Value Cost	132,220	335,760
20-Year Production, Tons	300,000	300,000
Net Present Value Cost per Ton	$0.44	$1.12

included and slightly lower than the hammermill shredder when idle was not included. The hammermill produced a finer discharge material particle size, which may be beneficial or detrimental for handling and combustion.

Only one analysis was required for the 50-TPD Navy facility under this contract, and normally this would have been conducted for the shear shredder due to its ability to shred the Navy waste and its anticipated safety advantages. However, the shear shredder had a measured, average daily production of 295 tons compared to 75 for the hammermill. As a result, it was believed both shredders should be considered in this projected cost analysis. A better match between the hammermill average throughput rate and the Navy 50-TPD facility, may have made the hammermill a cost-effective alternative compared to the shear shredder. An analysis was conducted for each.

PROCEDURE

For each shredder, analyses were done, both, including the capital facilities costs and considering the capital facilities costs as sunk costs. The analyses assumed a 250 day/year (50 weeks x 5 days/week) shredding station operation was sufficient to produce the fuel required for a heat recovery incinerator. In general, the approach was the same as that for the Charleston County SWRC life cycle cost analyses. Nonetheless, there were some very important differences.

The major differences involved the solid waste. First a value of $5/ton was assigned to the RDF-2 (coarse-shredded MSW) produced from this facility. Second, the landfill cost was considered to be $8.50 per ton (the actual Charleston, SC amount) instead of the estimated $1.00/ton incremental cost required to landfill unshredded as opposed to shredded MSW. Assigning a value to the RDF, reduced the cost of shredding by adding a product revenue stream. This was apparent for both the shear shredder and the hammermill shredder scenarios. Utilizing the actual Charleston landfill cost, preferentially favored the shear shredder. Less than 1% of the Navy waste sampled in this program was expected to create operational problems in the shear shredder. On the other hand, over 15% was found to be difficult-to-shred or unshreddable in the hammermill and was expected to have been bypassed to the landfill.

Another key difference was made to the operations and the labor requirements. The operations labor, which was estimated by Charleston County officials to be 12 man-hours (shear shredder) and 11 man-hours (hammermill) per shift, was reduced by a ratio of 8 man-hours divided by the above. It was believed the extra one-half man-day would not be required in the Navy facility. Since the total annual production of the facility was low compared to the annual capacity of each shredder, fixed labor costs (operation, maintenance, repairs) were proportionally increased by the ratio of the annual capacity of each shredder divided by the annual production of the Navy facility.

Finally, since each shredder would operate at less than capacity, it was assumed the shredders would not be allowed to idle (be energized, but not shred) or process at an unproductive capacity, but would process for shorter periods at the measured average capacity determined in this program. As a result the relatively fixed costs, such as labor, were increased on a cost-per-ton basis, but the power consumption costs/ton remained the same. Also, the life expected for each shredder was increased from the NAVFAC guideline for operating equipment of 10 years to 12 years.

The two year extension of the useful service lives of both shredders for the Navy facility were based on the fact that the shear shredder would operate at only 17%, and the hammermill would operate at 71% of its demonstrated capacity. The additional two years had the effect of increasing the projected life cycle period to 25 years -- two times the service life of the shredders plus, in the preferred analysis, a one year construction period. The service life of the shear shredder was not extended beyond that of the hammermill in case detrimental factors could be caused by operating the shear shredder at less than 20% capacity. A decision was made to stay with the rated capacity shear shredder rather than to scale down to a smaller unit. This was done to maintain the 50" by 96" throat opening of the shredder to physically allow the bulkier waste to be shredded rather than bypassed and landfilled.

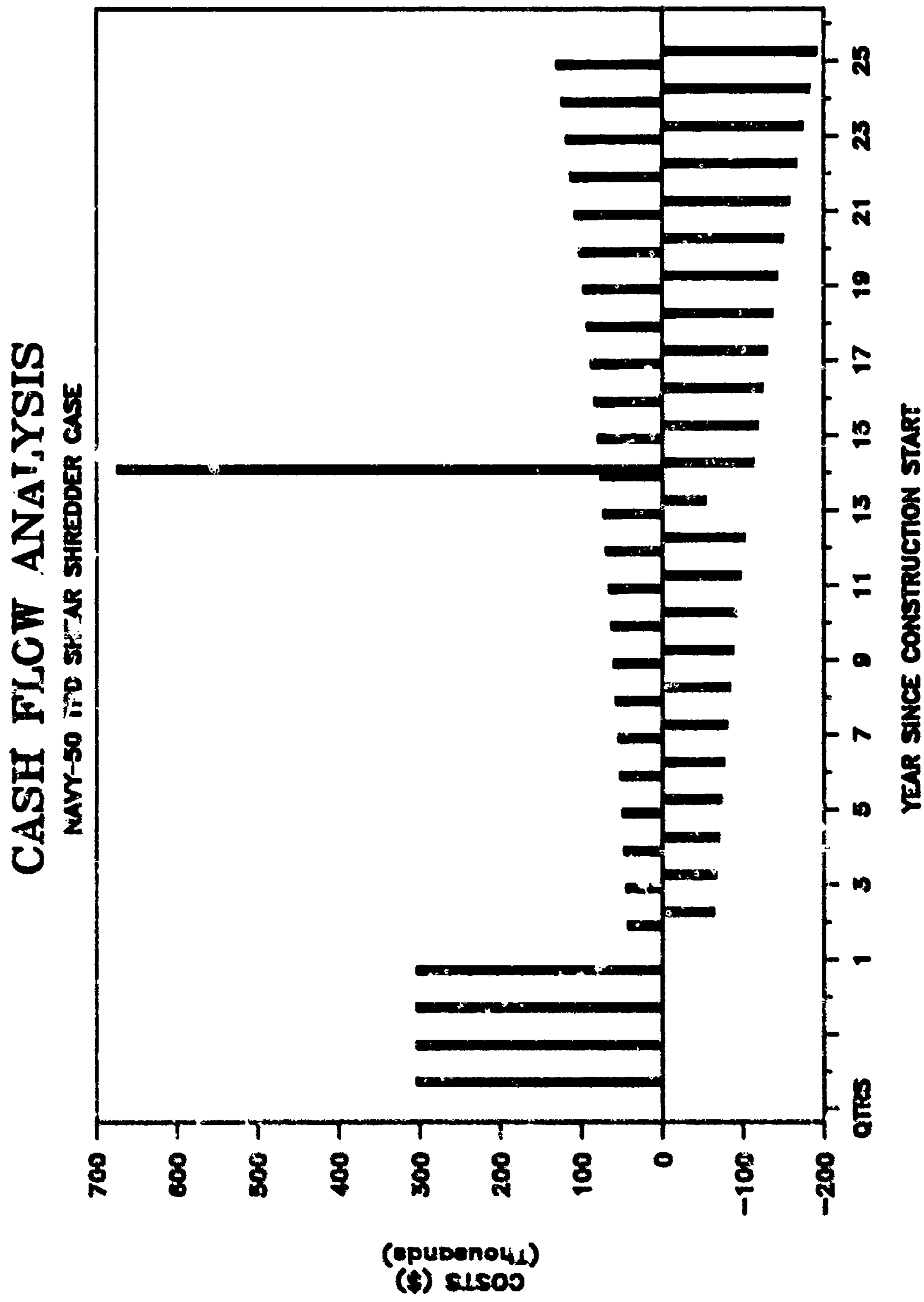
DISCUSSION OF RESULTS

Cash flow analyses for a Navy, 50 TPD shredding station were developed. A cash flow diagram for the shear shredder, requiring a new facility, is shown in Figure 4-1. The figure shows the capital cost of the facility distributed quarterly over the first year of the project. This is the construction phase and was expected to be completed in one year. Above the axis, during Years 2 through 25, are the operation and maintenance costs, escalated at 5% annually. Below the axis, is the refuse-derived fuel revenue valued at $5/ton in 1985, also escalated 5% annually. At Year 13, twelve years after initial operations, the shredder is replaced. This produced a high capital outlay and fuel revenue one-half than normally expected, due to lost production during shut-down of the plant.

The analysis for the Navy 50 TPD facility showed all the trends of the equipment performance evaluation, RAM analyses, and Charleston County SWRC life-cycle cost analyses. Result of the analyses are shown in Table 4-1. More detailed information is shown in Appendix L.

In the expected case, when a new facility had to be constructed, the present value capital costs were again less for the hammermill-shredding approach than for the shear shredder

Figure 4-1


CASH FLOW ANALYSIS
COSTS ($) (Thousands)
YEAR SINCE CONSTRUCTION START
QTRS

($989,620 compared to $1,142,100). The present value of shredder replacements of Year 13, were also much lower for the hammermill ($268,000) than the shear shredder ($367,710).

A completely different result was found in the operating and maintenance costs compared to the Charleston SWRC case. Because the shear shredder was operated at such a low percentage of capacity, the operating and maintenance costs were lower than those for the hammermill. The difference was $517,000 versus $683,000 when calculated on a present value basis. Also, the shear shredder could physically handle more material, producing higher fuel revenues. The life-cycle present value of the fuel was $746,880 for the shear shredder and $634,030 for the hammermill. The operating and maintenance cost savings and the extra fuel revenues more than compensated for the higher capital costs of the shear shredder and produced a net present value cost per ton for shredding of $4.27. The hammermill net present value was $4.36.

A similar result was found for the scenario in which the capital cost for a facility was not required. Again, the present value of the shredder replacement favored the hammermill ($280,760 compared to $385,220). However, operating and maintenance costs were less for the shear shredder ($569,000 versus $752,000) and RDF revenues were higher ($822,000 versus $697,000) on a present value basis such that the net present value of shredding was $0.44/ton for the shear shredder. For hammermill shredding, there was an associated net present value cost of $1.12/ton of waste delivered. RDF revenues were different in this case because RDF was produced during Year 1 through Year 24 rather than Year 2 through Year 25.

CONCLUSIONS ON NAVY 50-TPD FACILITY

Although the exact numbers will vary with site-specific conditions of power cost, labor cost, type of waste, and so forth, the general trend has consistently shown the shear shredder to offer substantial savings compared to the hammermill. Some of the life-cycle cost analyses assumptions were based upon contractor experience. However, the key elements which drove the cost of shear shredding to be more economical than the hammermill shredding operation, were the parameters which were measured during 6-month performance testing under this contract. Specifically, those parameters were the higher throughput capacity and the lower labor and electrical power costs per ton of waste processed for the shear shredder. It should be noted that these analyses assumed all shredded products were consumed as fuel. Also, there was no benefit assigned to the finer-sized product from the hammermill shredder.

Section 5

REFERENCES

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(2) Naval Facilities Engineering Command. P-442: Economic Analysis Handbook. June 1975 (AD A020859).

(3) Black, Richard Z., County Manager, Charleston, SC. "County Refuse Disposal System Meets Today's Needs," Public Works Magazine, June 1975.

(4) "Shear Shredder Demonstration", New York State Energy Research and Development Authority (Draft Copy) by Waste Energy Technology Corporation, July, 1985.

(5) C. Edward Walton, Lawton Engineering, Inc. and Gene LeBoeuf, O&E Shredding Systems, Private Communication, November, 1985.

(6) Frank Harling, Lindemann Recycling Equipment, Inc., Private Communication, January, 1986.

Appendix A

CEDARAPIDS 5096 SHEAR SHREDDER
MANUFACTURER'S DATA

Form 15269
Replaces 15269 6-80

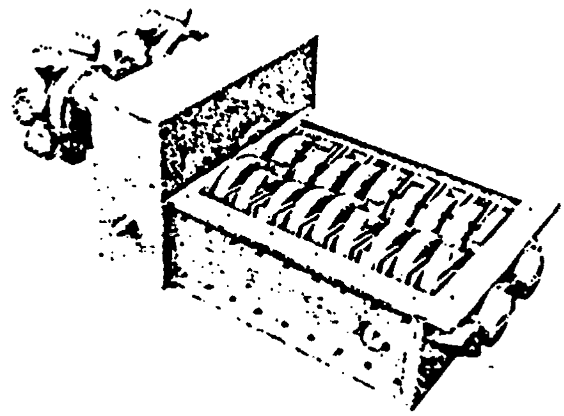
Wastes Processing Stations

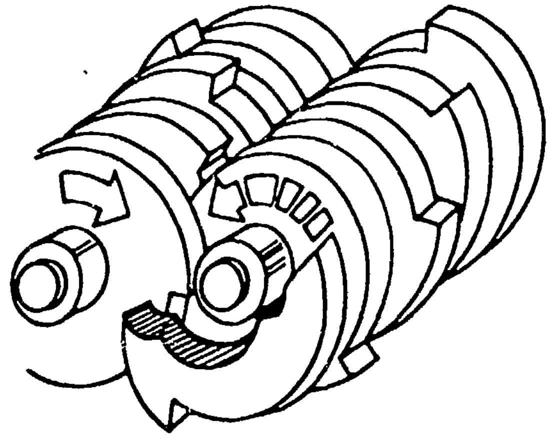
Iowa Manufacturing Company

SHEAR TYPE SHREDDERS

for municipal solid wastes

MODELS 4672RS & 5096RS





Rotary shear shredders will virtually shred wastes including those which cause problems in hammermill type units and turn out a cleaner, more uniform product for use in combustible-waste recovery systems.

Depending on the type of waste being handled, the Model 4672RS can shred up to 30 TPH and the Model 5096RS up to 60 TPH.

The shredder handles all types of mixed wastes, from paper products to white goods, simultaneously. No prior separation is necessary nor are special cutters needed for particular types of refuse.

Paper, cardboard and newsprint are shredded with ease in loose or baled form. These units also slice through troublesome materials such as foam rubber, bed springs, mattresses, carpeting, wire and cable, steel-belted tires, pallets, batteries, etc.

Cities and towns faced with limited disposal areas can prolong the useful life of landfills by shredding municipal wastes. Shredded wastes reduce volume, compact better and discourage infestation by rodents.

The shredded product is one from which heavy and noncombustible material can be readily separated in subsequent processing units. This leaves the combustible material for use as a high quality energy source.

In addition, the slicing action and low operating speed produce a minimum of fines, considered a contaminant in combustible-waste recovery. Glass, for instance, will tend to break into large pieces rather than be pulverized into fine shards which imbed in the combustibles.

Nor does the material tend to clump or ball up, making further processing more difficult.

The shredder operates at low speed — one shaft about 40 RPM, the other about 20 RPM. This reduces noise, dust and minimizes hazards from flying debris. The possibility of explosions, which have occured in hammermill type units is almost eliminated.

The shredder is jam proof. It will reverse itself to clear the jam and return to normal operation automatically.

The shredder has two rows of counterrotating cutter-discs, keyed to shafts. The cutters closely mesh during rotation.

Material is caught by teeth on the cutters and pulled into the center cutting zone. The edges of the cutters slice through the material to produce a uniform-sized product. Cutters can be alternated or replaced with ones of different width to provide different product sizes.

The shafts are driven by a radial piston hydraulic motor(s) from a patented hydraulic drive system normally powered by electric motors. If hydraulic pressure rises too high due to potential jamming, a switch will cause the hydraulic system to flow automatically reverse. The shafts rapidly reverse rotation and lift the material free.

A time-delay switch automatically reverses the flow again to resume full speed normal shredding and maintaining torque

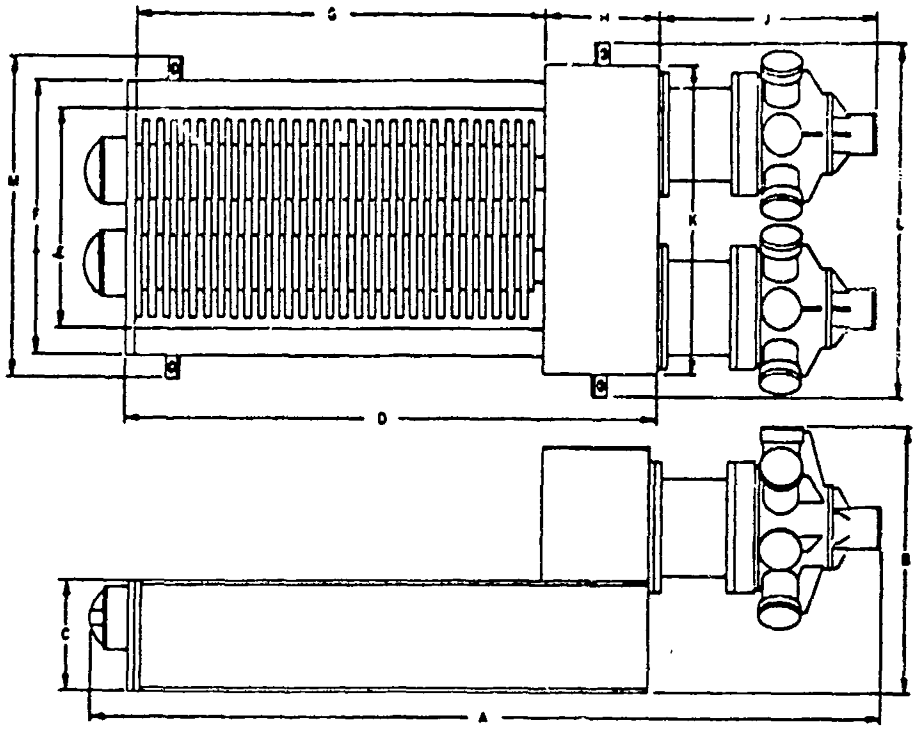
The jamming and anti-jamming cycle can occur repeatedly without stress on the shredder or drive system. At no time does the electric motor, hydraulic pump or other power supply component reverse direction. Down-time for drive-train problems is virtually eliminated.

Other safeguards include automatic high temperature and low-oil level cutoffs.

POWER PACKAGE: Includes specially insulated electric motors for 220-440-3-60 power, control panel with start-stop buttons and indicator lights.

HYDRAULIC PACKAGE: Includes pump, pump drive motors, oil reservoir, heater and cooler, high temperature and low oil-level cutoffs

MODELS 4672RS & 5096RS SHREDDER SPECIFICATIONS



Dimensions to nearest inch and (mm)

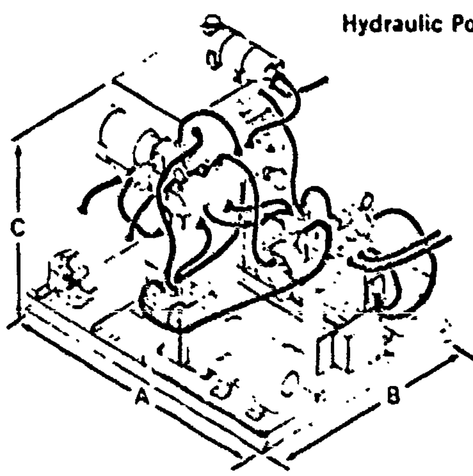
Model	4672	5096
A	147 (3,734)	175 (4,445)
B	45 (1,143)	52 (1,321)
C	21 (533)	26 (660)
D	96 (2,438)	131 (3,327)
E	46 (1,[illegible])	50 (1,270)
F	59 (1,498)	65 (1,650)
G	72 (1,829)	96 (2,438)
H	22 (559)	24 (609)
J	51 (1,295)	42 (1,067)
K	64 (1,626)	70 (1,778)
L	74 (1,880)	80 (2,032)
M	69 (1,753)	74 (1,880)

Dimensions to nearest inch and (mm)

Model	Inside Measurements Width	Length	Depth	Shaft Dia.	Cutter Dia.	No. of Cutters	Cutter Width	Tooth force lbs.	Optional Cutters	Reservoir gal. (m³)	Elec. HP**	Weight lbs. (kg)
4672	46 (1,168)	72 (1,829)	21 (533)	6¾ (171)	24½ (622)	48	1½ (38)	48,200 (21,863)	1 (25)	140 (.53)	2-150	27,200 (12,338)
5096	50 (1,270)	96 (2,438)	26 (660)	8 (203)	26½ (673)	48	2 (51)	35,357 (16,038)	1 (25)	280* (1.1)	2-300	40,000 (18,144)

*Two 140-gal. reservoirs.
**Model 5096 requires two hydraulic power packs, each powered by two 150 HP motors.

Hydraulic Power Pack



Dimensions to nearest inch and mm

	A	B	C
U.S.	96	72	51
(mm)	2,438	1,829	1,295

Iowa Manufacturing Company

CEDAR RAPIDS, IOWA • U.S.A. • 52402

Design and specifications subject to change without notice

Sales Manual
Section 20
Form 15269-IMCO-12-80

A Raytheon Company

IOWA MFG. CO. SHREDDER, MODEL 5096

HORSEPOWER	200
NO. MOTORS	2
NO. HYDRAULIC PUMPS, TYPE, SIZE	2 Dynapower
HYDRAULIC PUMPS DISPLACEMENT	21"
TOTAL HYDRAULIC FLOW TO MOTOR	158 x 2 GPM
HYDRAULIC MOTOR MODEL	MRH 525 x 2
HYDRAULIC MOTOR DISPLACEMENT	523.9 x 2 in 3/rev
HYDRAULIC MOTOR SHAFT SPEED	70 RPM
HYDRAULIC MOTOR TORQUE	19,520 x 2 ft/lb
SHAFT TORQUE	
SLOW SHAFT	39,040 ft/lb
FAST SHAFT	30,646 ft/lb
GEAR RATIO	
SLOW SHAFT	2.000:1
FAST SHAFT	1.570:1
SHAFT SPEED	
SLOW SHAFT	35 RPM
FAST SHAFT	45 RPM
CUTTER DIAMETER	26.5 Inches
CUTTER FORCE	35,357 lbs.
FEED OPENING AT CUTTERS	96" x 50"
SHREDDER DIMENSIONS (L x W x H)	157" x 70" x 60"
HYD. POWER PACK DIMENSIONS (L x W x H)	(2) 72" x 96" x 61"
ESTIMATED WEIGHT TOTAL UNIT*	52,000 lbs.

*Hopper and Stand Not included in price or weight.

ESTIMATED THROUGHPUT CAPACITIES

GARBAGE	35-60 TPH	WHITE GOODS	2.5 - 5 TPH
PAPER/CARDBOARD	7.5-10 TPH	COPPER WIRE/ACSR/ALUM. CABLE	4-6 TPH
ALUMINUM SCRAP	5-7 TPH	LOOSE STEEL CABLE	3-4 TPH
FERROUS #16	4-5 TPH	TIRES-PASSENGER . (2" CUT)	800-1000/Hr*
LEAD BATTERIES	20-30 TPH	TIRES-TRUCK . . . (2" CUT)	150-200/Hr*
WOOD PALLETS	400/Hr	STEEL CANS	10-15 TPH
55-GALLON DRUMS	500/Hr	ALUMINUM CANS	5-7.5 TPH

*Tires-Passenger. . . . (4" Cut). 1200-1400/Hr
Tires-Truck. . . . . . (4" Cut). 360/Hr

IOWA MFG. SHREDDER
MODEL 5096, 400 HP

GARBAGE	35-60 Tons Per Hour
PAPER/CARDBOARD	15,000-20,000 Lbs/Hour
ALUMINUM SCRAP	10,000-14,000 Lbs/Hour
FERROUS #16 AND BELOW	8,000-10,000 Lbs/Hour (Med. Gauge)
LEAD BATTERIES	40,000-60,000 Lbs/Hour (Industrial)
WOOD PALLETS	400 Per Hour (Heavy)
55-GALLON DRUMS	500 Per Hour
WHITE GOODS	5,000-10,000 Lbs/Hour (Medium)
COPPER WIRE/ACSR/ALUM. CABLE	8,000-12,000 Lbs/Hour (Med. - Heavy)
LOOSE STEEL CABLE	6,000-8,000 Lbs/Hour (Med. - Heavy)
TIRES - PASSENGER - 2" CUT	800-1000 Tires per Hour
TIRES - PASSENGER - 4" CUT	1,200-1,400 Tires per Hour
TIRES - TRUCK - 2" CUT	150-200 Tires per Hour
TIRES - TRUCK - 4" CUT	360 Tires per Hour
STEEL CANS	20,000 - 30,000 Lbs/Hour
ALUMINUM CANS	10,000 - 15,000 Lbs/Hour

IOWA MFG. SHREDDERS THROUGHPUT RATE AND SHRED SIZE POLICY

The above rates of throughput have been determined by testing representative samples, and have been extrapolated to approximate shred rates for the various materials.

Iowa Manufacturing Company will not guarantee any throughput rates or shred sizing required by any customers or representatives. Nor will we be responsible for any such guarantee made by its representatives to any customer of Iowa Mfg. Company. This information on this sheet is an approximation of actual data as well as theoretical data of throughput rates. These are not to be warranted nor guaranteed in any shape or form. This data is to be used only to show the difference in capabilities of the various shredders. Throughput rates can be greatly affected by material size, mode of input feeding, size of hopper, opening and design, size or shredder, horsepower, cutter size, and in no manner be approximated without specific testing of the material.

Appendix B

HEIL 42-F VERTICAL-SHAFT HAMMERMILL
MANUFACTURER'S DATA

THE HEIL CO.
3000 W MONTANA ST., P O BOX 583, MILWAUKEE, WISCONSIN 53201, U S
TELEPHONE (414) 647-3333 • CABLE ADDRESS HEILCO • TELEX 026-6

July 7, 1980

MODEL 42F SERIES SHREDDER SPECIFICATIONS

1.1 Scope

This specification describes the Heil Model 42F Vertical Shaft, Dual Rotation Shredder.

1.2 Specifications

a) Rated Capacity — 10 - 25 TPH* (Unprocessed Refuse)

b) Overall Dimensions

	Length	Width	Height
Basic Shredder	11'-1-3/8"	10'-4"	9'-9-3/4"
Shredder with Infeed, Reject and Discharge Hoods	15'-5"**	13'-3"**	16'-1-1/2"

c) Throat Diameter — 42"

d) Infeed Opening — 36" x 66"

e) Weight — 15,700 lbs

f) Motor Horsepower — 250 HP

g) RPM — 1200 Nominal

1.3 Construction

1.3.1 Body

The body cylinder is 4'-4-1/4" diameter x 5'-5-9/19" high and is made of 5/8" HRS. A motor mounting frame 19-1/4" high x 33" wide is fully welded to the body cylinder directly opposite the discharge opening. It is made of 5/8" HRS with a 1" HRS top plate and is reinforced with six vertical stiffeners made of 5/8" HRS. The motor mounting frame has a 14-1/2" high x 18" wide screened access opening on each side of the motor mounting frame and one 16" wide x 14-1/2" high screened access opening on the rear of the frame.

The body cylinder and motor frame are fully welded to a common 5/8" HRS base plate.

The 1-1/2" thick flange welded to the upper portion of the cylinder provides a mating surface for the upper cone portion of the shredder. Flanges and cylinder are reinforced with six 5/8" HRS vertical stiffeners, fully welded to the cylinder, base plate and upper flange.

The cylinder body has two 14-1/2" high x 18" wide screened access openings and two 18" wide x 24-3/8" high access openings with hinged doors located 30" above the base plate. The access doors are curved to the contour of the cylinder body and made of 5/8" HRS. They are reinforced with two 5/8" thick x 4-1/2" wide horizontal stiffeners and six 1/2" thick vertical stiffeners.

The discharge opening is 29" wide and can be adjusted to 5", 10", or 15-1/2" in height, depending on customer particle size requirements.

Entire body section is bolted to upper cone section by twelve 1" diameter bolts equally spaced at 30°. Base and discharge can therefore, be positioned at any one of 12 locations with respect to the infeed opening.

1.3.2 Liners

1/2" thick cone liners are held in place by countersunk bolts and external nuts.

1-1/4" thick ribbed cast manganese grind chamber liners are retained by countersunk bolts and locknuts.

Discharge lip liners of 1-1/2" thick cast manganese are held by countersunk bolts and nuts.

Other areas are protected by 2" thick HRS liners.

1.3.3 Top Bearing Support

The top bearing support separates the infeed and reject openings and is 24-3/4" wide x 121-1/4" long x 11-3/8" high. It is made of, and reinforced with 7" channels fully welded to the 1/2" thick base plate. This support is bolted to the top of the cone for shipping.

1.3.4 Reject Hood

This hood is mounted on top of the shredder opposite the infeed hood. Construction is of 3/8" plate, fully welded with a 22" x 24" access door in the rear sloping panel.

It is designed to give an escape point for all heavy non-reducible items. This is done by deflecting them in an upwards path over the extended cone side and downward through external reject chute.

1.3.5 Infeed Cover

Consists of 1/2" HRS cover plate complete with 2" x 1-1/2" x 1/4" angles framing the infeed opening and is bolted to top of cone and bearing support frame.

1.3.6 Infeed Hood

The infeed hood is made of 3/16" plate and includes a 36" x 24" access door. A rubber seal connects the hood to the shredder infeed cover. Hood is supported by infeed conveyor framework.

1.3.7 Rotor Assembly - General

Rotor assembly consists of a 6-5/8" diameter x 104-1/8" long shaft with fifteen rotor hubs stacked to provide a 74" long working area.

Stacked rotor hubs and discs permit fourteen layers of hammers with provisions for a wide variety of hammer patterns and quantities in each layer.

A total of 38 hammers are normally used for primary shredding of municipal refuse. Other quantities and hammer patterns are available from Heil for special shredding applications.

Hammer shafts are staggered to allow rapid selective removal of hammers. Tip to tip distance of hammers in upper section is 32-1/2", in the middle section 27-1/2", and in the lower section 42-1/2". Rotor assembly WK^2, complete with standard hammer compliment, is 2920 lb/ft^2.

The main shaft is constructed of 4140 steel.

Diameter at center of rotor area	-	6.623"
Diameter at bearings - top radial	-	4.921"
- bottom radial	-	5.905"
- bottom thrust	-	5.118"
Diameter at sheave	-	4.125"

1.3.8 Rotor Hubs and Discs

Each rotor segment consists of a 3/4" or 1" HRS disc welded to a 6-5/8" I.D. x 9-1/4" or 10-1/2" OD cast steel hub. Hub and disc assembly is keyed to main shaft. Discs vary in diameter from 18" to 29" and are furnished with 3" diameter 1117 CFR hammer spaces.

1.3.9 Hammers

Material	1060 HR Bar
Type	Free Swinging
Weight	14.25 lbs. each
Quantity	38 ***

1.3.10 Hammer Shafts

Rotor contains 18 1-3/8" diameter 1144 CDS stress-proof hammer shafts. Six shafts (22-7/8" long) in the upper rotor section, six shafts (32-1/2" long) in the middle rotor section and six shafts (32-1/2" long) in the lower rotor section. Shaft ends are drilled and tapped for ease of removal.

1.3.11 Rotor Shaft Bearings

Top Radial:	SKF double row spherical roller bearing
Bottom Radial:	SKF double row spherical roller bearing
Bottom Thrust:	SKF single row spherical roller bearing

1.3.12 Rotor Shaft Bearing Seals

Bearing seals are double labyrinth backed by neoprene oil seals.

1.4 Lubrication

Top bearing is grease packed and replenished by grease gun through grease fitting in bearing housing cap.

Bottom bearings are lubricated and cooled by automatic system utilizing bottom thrust bearing for circulation.

1) Lube tank is complete with base plate, cover, drain plug, return line, feed line and overflow line entrance ports.

1) Oil level gage.

1) Oil level switch.

All necessary tubes and fittings for connecting to lower bearing housing.

Lube system is bracket mounted directly to the side of the shredder and is shipped completely assembled.

1.5 Motor - T.E.F.C.

250 HP, 447 TD, "T" Frame - "D" Flange, vertical (shaft down) induction motor. 3 phase. 60 hertz. 460 volt. 1750 RPM. Class "F" insulation. Motor will be manually reversed and is protected by three normally closed heat sensors. Motor to be furnished with space heaters and mounted on slide base.

1.6 Drive

Consisting of the following:

1) 6 groove 8V - 13.2" O.D. A-2 web center QD type sheave.

1) 6 groove 8V - 20.0" O.D. B-3 arm center QD type sheave.

2) QD type bushings.

1) Set of 2 matched 3 groove 8V 1500 V-belts.

* Depends on customer requirements, throughput, particle size, etc.

** Assumes discharge direction perpendicular to infeed, can be located in 12 locations (30° increments).

*** A normal compliment of 38 hammers produces shredded material 90% minus 3".

Other quantities and hammer patterns are available, depending on customer particle size requirements.

Vertical shaft design— its massive impact and shearing action are the keys to efficiency and economy

Heil shredders are uniquely designed and constructed to handle a heterogeneous assortment of commercial, industrial and municipal solid waste. They are not modified, converted or updated units which were originally designed and manufactured to shred only homogenous materials. The Heil shredder is designed specifically for refuse.

The Unique Vertical Shaft Principle

The Heil shredders are unique by design — different from all other shredders in today's market. For an "up-close" look at this vertical shaft design, follow the solid waste through the cutaway drawings on the next page. The vertical shaft principle embodied in the Heil shredder results in the following installation economies and operational advantages.

Reduced requirements for concrete foundations.

Horizontal discharge can be located in any of 12 positions for a trouble-free flow of refuse onto an economical rubber belt discharge conveyor. No expensive metal discharge conveyor is required to remove the shredded material.

Cone shape and decreasing clearances between hammers and shredder liners combine to produce a gradual reduction in particle size. Smooth shredding action eliminates need for grates, resulting in low power consumption and reduced maintenance costs.

Low height of infeed hood reduces machine height which in turn means lower building enclosure height. Lower infeed hood can be used because hammers swing in a horizontal plane and do not throw items upward as in horizontal shaft shredders.

Heil shredders are much less subject to damage because large, non-shreddable objects are ballistically rejected. This ejection principle assures less wear-and-tear and a very high percentage of machine availability.

Heil shredders are designed for *dual rotation*, so hammer life is greatly increased prior to changing or rebuilding.

There are no grates to become clogged, broken and worn-out, causing costly maintenance, downtime and replacement problems.

Only those hammers in the final grind stage are susceptible to heavy wear. These final grind hammers are readily accessible for replacement or rebuilding.

Ferrous recovery product density accomplished by Heil shredders is highly acceptable for the detinning and copper precipitation markets.

The Heil Method of Shredding

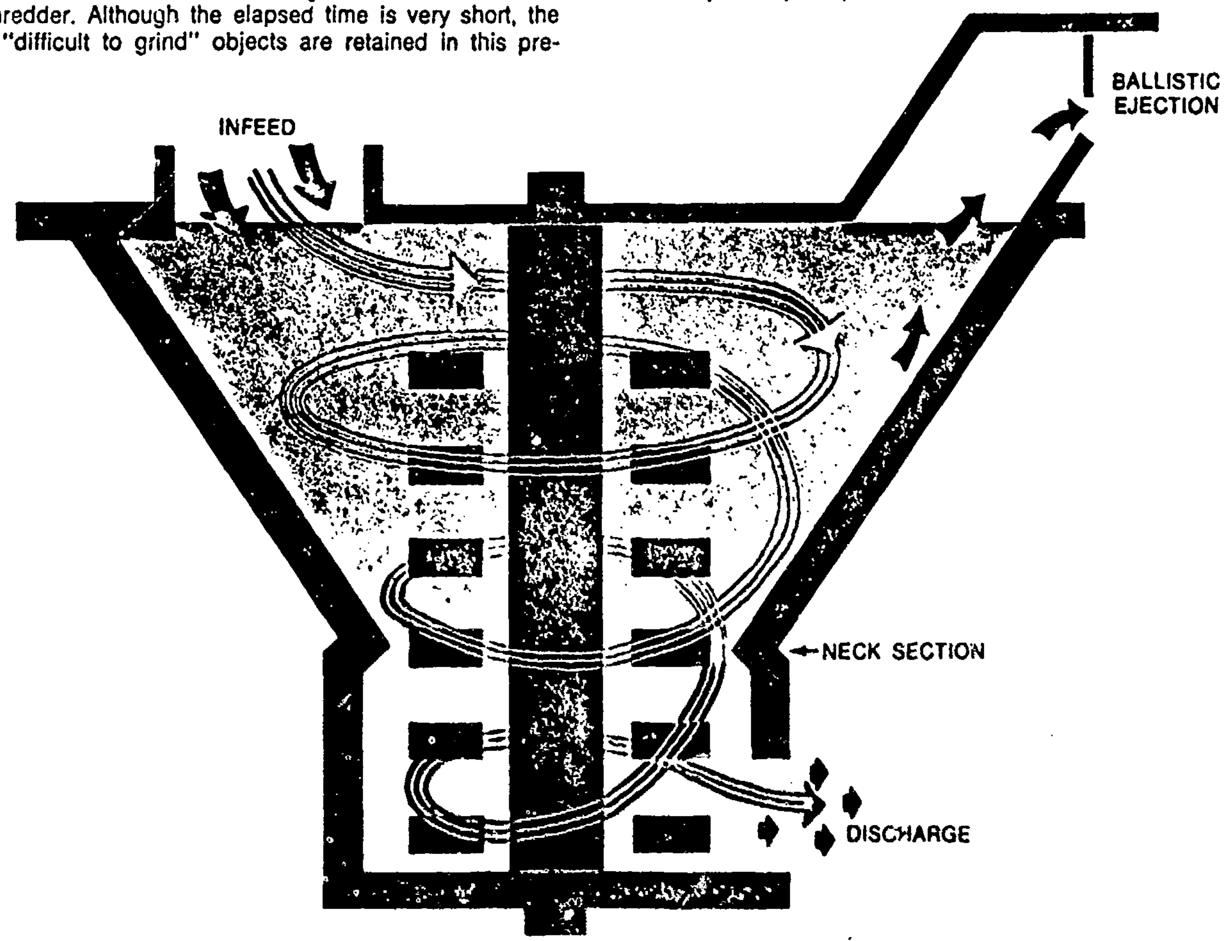
The Heil vertical shaft principle is only part of the story. It is also the uniquely rugged way the Heil shredder is constructed that makes possible the best end results. The Heil shredder permits an infinite combination of components to produce any desired shredded product sizing.

Shearing Action: The Heil vertical shaft design allows the incoming material to drop through the free swinging hammers. The hammers perform their efficient shearing action by impacting the material as it drops through the machine. Heil employs a relatively thin, flat hammer, eliminating the need for costly grates at the discharge opening. Heil's efficient shearing action, combined with the cone shape of the prebreak section, reduces the total horsepower requirements as compared to other types of grinding equipment.

Hammer configuration: If more hammers are incorporated in the shredder, it will substantially increase the WK^2 (an expression of the weight and radius of the rotor parts) and the number of cutting edges. The Heil shredder can incorporate infinite hammer pattern arrangements in order to vary the sizing of the shredded product. Each Heil shredder can be custom-designed to match the application. Once the motor has been sized for optimum inertia requirements, the Heil shredder can be adapted for a variety of particle sizes — simply by adding or subtracting hammers. No other alterations or costly grate changes are required to change the particle sizing.

Ballistic separation principle: There are some objects that either cannot or should not be ground to a small particle size. The Heil patented ballistic ejection feature minimizes jams and damage to the shredder by ejecting oversize and hard-to-grind objects such as hardened, dense metal objects. Such objects are propelled through a reject hood on top of the shredder opposite the infeed opening. This ballistic ejection is initiated at the second stage of grinding. See cutaway drawing for details. The automatic ejection feature serves as a safety valve for the equipment and reduces the need for costly and time-consuming removal of items from the refuse to be processed. No additional power or ancillary equipment is necessary for this most important feature.

FIRST STAGE Raw refuse enters the shredder through a large infeed opening. All material to be shredded remains *inside* the machine and is not thrown back up into the infeed hood, as is the case with most other designs. The Heil infeed hood serves only to direct the unprocessed solid waste into the shredder. Massive hammers start the reduction process. The clearance between the shell of the machine and hammer swing diameter changes dramatically as the material travels downward through the conical section of the shredder. Although the elapsed time is very short, the more "difficult to grind" objects are retained in this prebreak section until sufficient destruction allows the objects to drop further into the grinding section. Easier material continues through the three stage process without interruption while difficult material remains in the prebreak section. Hard to destruct items such as high alloy forgings and castings receive numerous blows from the hammers until they are either reduced to sufficient size to enter the 2nd and 3rd stages of the shredder or are discharged by the exclusive ballistic ejection principle.



SECOND STAGE We refer to this area as the "neck" section of the mill. At this point, there is the least amount of clearance between the hammers and the outer shell. Here, the particle size must be sufficiently reduced to allow it to drop down into the final stage of grinding. Items that are not further reducible are spun out of the neck section and are thrown back up the conical section and out the ballistic ejection opening. The amount of material ejected will vary with the incoming mix. The amount of rejected material can be controlled by adjusting the size of the reject opening and the flexible rubber curtain. Normal ejected material ranges from ½ of 1% to 3% by weight — an insignificant amount in terms of volume. In most installations, the rejected material is dropped harmlessly onto the common discharge conveyor along with the shredded material.

THIRD STAGE Once the partially shredded material passes the neck section, it enters the final grind stage where it is "battered" again by these same massive hammers against breaker bars (projections along the shell liners perpendicular to the swing of the hammers). The final shredded product is then swept out through the discharge opening. This aperture is an *unobstructed* opening. A discharge impact area of heavy steel construction absorbs the force of the shredded product, allowing the material to drop harmlessly onto a rubber belt discharge conveyor.

*The cutaway drawing shown is a "hybrid machine" which combines the configurations of all Heil shredders — the high volume Series 92, the high to medium volume Series 72 and the medium to low volume Series 42. While detailed design and construction varies on the three machines, basic operation is identical on all.

Appendix C

NAVY WASTE SAMPLES
INDIVIDUAL, REFINED DATA SHEETS

DATE 22-Feb

BASE ID BLDG 198

	SAMPLE N-1	UNSHREDDABLE SHEAR	UNSHREDDABLE HMML.	HARD TO SHRED SHEAR	HARD TO SHRED HMML.
GROSS WEIGHT, LBS.					
TARE WEIGHT, LBS.					
NET WEIGHT, LBS.	7340				
VOLUME, CU.FT.	1080				
USAGE	0.95				
NET VOLUME, CU.FT.	1026				
DENSITY, LB./CU.FT	7.2				
PAPER	6503	0	0	0	0
PLASTIC					
Light	80	0	0	0	0
Heavy	50	0	0	0	0
Other	60	0	0	0	0
RUBBER					
Tires					
Other					
CARDBOARD	420	0	0	0	0
TEXTILES	15	0	0	0	0
WOOD					
Pallets	25	0	0	0	0
Other	20	0	0	0	0
MISC. ORGANICS	100	0	0	0	0
GLASS	20	0	0	0	0
INERTS/CERAMICS	2	0	0	0	0
FERROUS					
Cable/Strapping	5	0	0	0	0
Other	15	0	0	0	0
NONFERROUS					
Cable					
Other	10	0	0	0	0
OTHER/SPECIAL					
Aerosol Can					
Paint					
Solvents					
Oil	15	0	0	0	0
Insulation					
TOTAL	7340	0	0	0	0
PERCENT		0.00	0.00	0.00	0.00

DATE				14-Mar		
BASE ID	N. Side		BLDG	1601		

	SAMPLE N-2	UNSHREDDABLE SHEAR	UNSHREDDABLE HMML.	HARD TO SHRED SHEAR	HARD TO SHRED HMML.
GROSS WEIGHT, LBS.					
TARE WEIGHT, LBS.					
NET WEIGHT, LBS.	5160				
VOLUME, CU.FT.	1080				
USAGE	0.90				
NET VOLUME, CU.FT.	972				
DENSITY, LB./CU.FT	5.3				
PAPER	20	0	0	0	0
PLASTIC					
Light	1380	0	0	0	0
Heavy	90	0	0	0	0
Other	30	0	0	0	0
RUBBER					
Tires					
Other	90	0	0	0	0
CARDBOARD	1956	0	0	0	0
TEXTILES	15	0	0	0	0
WOOD					
Pallets					
Other	820	0	0	0	0
MISC. ORGANICS	640	0	0	0	0
GLASS	60	0	0	0	0
INERTS/CERAMICS	1	0	0	0	0
FERROUS					
Cable/Strapping					
Other	45	0	0	0	20
NONFERROUS					
Cable					
Other	13	0	0	0	0
OTHER/SPECIAL					
Aerosol Can					
Paint					
Solvents					
Oil					
Insulation					
TOTAL	5160	0	0	0	20
PERCENT		0.00	0.00	0.00	0.39

DATE			21-Mar		
BASE ID	CIA Area	BLDG	228		
	SAMPLE N-3	UNSHREDDABLE SHEAR	UNSHREDDABLE HMML.	HARD TO SHRED SHEAR	HARD TO SHRED HMML.
GROSS WEIGHT, LBS.					
TARE WEIGHT, LBS.					
NET WEIGHT, LBS.	2940				
VOLUME, CU.FT.	1080				
USAGE	0.95				
NET VOLUME, CU.FT.	1026				
DENSITY, LB./CU.FT	2.9				
PAPER	3	0	0	0	0
PLASTIC					
Light	90	0	0	0	0
Heavy	5	0	0	0	0
Other	4	0	0	0	0
RUBBER					
Tires					
Other	60	0	0	0	0
CARDBOARD	2173	0	0	0	0
TEXTILES	175	0	0	0	45
WOOD					
Pallets	220	0	0	0	25
Other	3	0	0	0	0
MISC. ORGANICS	30	0	0	0	0
GLASS					
INERTS/CERAMICS	110	0	0	0	0
FERROUS					
Cable/Strapping	3	0	0	0	0
Other	20	0	0	0	0
NONFERROUS					
Cable					
Other	4	0	0	0	0
OTHER/SPECIAL					
Aerosol Can					
Paint					
Solvents					
Oil					
Insulation	40	0	0	0	0
TOTAL	2940	0	0	0	70
PERCENT		0.00	0.00	0.00	2.38

DATE			16-May		
BASE ID		BLDG	1603		

	SAMPLE N-4	UNSHREDDABLE SHEAR	UNSHREDDABLE HMML.	HARD TO SHRED SHEAR	HARD TO SHRED HMML.
GROSS WEIGHT, LBS.	36700				
TARE WEIGHT, LBS.	31940				
NET WEIGHT, LBS.	4760				
VOLUME, CU.FT.	1080				
USAGE	0.90				
NET VOLUME, CU.FT.	972				
DENSITY, LB./CU.FT	4.9				
PAPER	2315	0	0	0	60
PLASTIC					
Light	30	0	0	0	0
Heavy					
Other					
RUBBER					
Tires	2	0	0	0	0
Other					
CARDBOARD	1880	0	800	0	0
TEXTILES	65	0	62	62	0
WOOD					
Pallets	450	0	450	0	0
Other					
MISC. ORGANICS					
GLASS					
INERTS/CERAMICS					
FERROUS					
Cable/Strapping					
Other	12	0	0	0	0
NONFERROUS					
Cable					
Other	1	0	0	0	0
OTHER/SPECIAL					
Aerosol Can	1	0	1	0	0
Paint	3	0	0	0	0
Solvents					
Oil					
Insulation					
TOTAL	4759	0	1313	62	60
PERCENT		0.00	27.59	1.30	1.26

DATE	23-May				
BASE ID	BLDG 67				
	SAMPLE	UNSHREDDABLE		HARD TO SHRED	
	N-5	SHEAR	HMML.	SHEAR	HMML.
GROSS WEIGHT, LBS.	35840				
TARE WEIGHT, LBS.	32940				
NET WEIGHT, LBS.	2900				
VOLUME, CU.FT.	1080				
USAGE	0.90				
NET VOLUME, CU.FT.	972				
DENSITY, LB./CU.FT	3.0				
PAPER	1056	0	0	0	300
PLASTIC					
Light	48	0	0	0	0
Heavy	1	0	0	0	0
Other					
RUBBER					
Tires					
Other	16	0	0	0	0
CARDBOARD	1200	0	150	0	400
TEXTILES	1.5	0	0	0	0
WOOD					
Pallets	385	0	385	0	0
Other	83	0	39	0	0
MISC. ORGANICS	2	0	0	0	0
GLASS	1.5	0	0	0	0
INERTS/CERAMICS	15	0	0	0	0
FERROUS					
Cable/Strapping	29	0	0	0	0
Other	37	0	11	0	37
NONFERROUS					
Cable					
Other	24	19	19	0	0
OTHER/SPECIAL					
Aerosol Can	1	0	1	0	0
Paint					
Solvents					
Oil					
Insulation					
TOTAL	2900	19	605	0	737
PERCENT		0.66	20.86	0.00	25.41

DATE	30-May				
BASE ID	PIER Q				
	SAMPLE	UNSHREDDABLE		HARD TO SHRED	
	N-6	SHEAR	HMML.	SHEAR	HMML.
GROSS WEIGHT, LBS.	42000				
TARE WEIGHT, LBS.	32940				
NET WEIGHT, LBS.	9060				
VOLUME, CU.FT.	1080				
USAGE	0.95				
NET VOLUME, CU.FT.	1026				
DENSITY, LB./CU.FT	8.8				
PAPER	1450	0	0	0	0
PLASTIC					
Light	80	0	0	0	0
Heavy	40	0	0	0	0
Other					
RUBBER					
Tires					
Other	470	0	430	0	0
CARDBOARD	800	0	0	0	0
TEXTILES	390	0	0	0	30
WOOD					
Pallets					
Other	30	0	0	0	0
MISC. ORGANICS	5500	0	0	0	0
GLASS	40	0	0	0	0
INERTS/CERAMICS	60	0	0	0	60
FERROUS					
Cable/Strapping					
Other	90	0	40	40	0
NONFERROUS					
Cable	29	0	0	0	0
Other	76	0	0	0	0
OTHER/SPECIAL					
Aerosol Can	4	0	0	0	0
Paint					
Solvents	1	0	1	0	0
Oil					
Insulation					
TOTAL	9060	0	471	40	90
PERCENT		0.00	5.20	0.44	0.99

DATE		11-Jul			
BASE ID		PIER M			
	SAMPLE	UNSHREDDABLE		HARD TO SHRED	
	N-7	SHEAR	HMML.	SHEAR	HMML.
GROSS WEIGHT, LBS.	41420				
TARE WEIGHT, LBS.	32920				
NET WEIGHT, LBS.	8500				
VOLUME, CU.FT.	1080				
USAGE	0.95				
NET VOLUME, CU.FT.	1026				
DENSITY, LB./CU.FT	8.3				
PAPER	790	0	0	0	0
PLASTIC					
Light	90	0	0	0	0
Heavy	30	0	0	0	0
Other					
RUBBER					
Tires					
Other	20	0	0	0	0
CARDBOARD	1100	0	0	0	0
TEXTILES	195	0	0	0	0
WOOD					
Pallets	70	0	0	0	0
Other	1400	0	450	0	1000
MISC. ORGANICS	4453	0	0	0	0
GLASS	78	0	0	0	0
INERTS/CERAMICS					
FERROUS					
Cable/Strapping	9	0	0	0	0
Other	105	0	40	0	20
NONFERROUS					
Cable					
Other	100	0	0	0	12
OTHER/SPECIAL					
Aerosol Can					
Paint					
Solvents					
Oil					
Insulation	60	0	0	0	0
TOTAL	8500	0	490	0	1032
PERCENT		0.00	5.76	0.00	12.14

DATE			25-Jul		
BASE ID		BLDG	1502		
	SAMPLE	UNSHREDDABLE		HARD TO SHRED	
	N-8	SHEAR	HMML.	SHEAR	HMML.
GROSS WEIGHT, LBS.	34920				
TARE WEIGHT, LBS.	31680				
NET WEIGHT, LBS.	3240				
VOLUME, CU.FT.	1080				
USAGE	0.85				
NET VOLUME, CU.FT.	918				
DENSITY, LB./CU.FT	3.5				
PAPER	190	0	0	0	0
PLASTIC					
Light	128	0	0	0	0
Heavy					
Other	6	0	0	0	0
RUBBER					
Tires					
Other					
CARDBOARD	1494	0	400	0	75
TEXTILES	4	0	0	0	0
WOOD					
Pallets	670	0	670	0	0
Other	650	0	275	0	125
MISC. ORGANICS					
GLASS	5	0	0	0	0
INERTS/CERAMICS	70	0	0	0	0
FERROUS					
Cable/Strapping	20	0	0	0	0
Other					
NONFERROUS					
Cable					
Other	1	0	0	0	0
OTHER/SPECIAL					
Aerosol Can	1	0	0	0	0
Paint					
Solvents					
Oil					
Insulation					
TOTAL	3239	0	1345	0	200
PERCENT		0.00	41.53	0.00	6.17

DATE 15-Aug

BASE ID BLDG 25

	SAMPLE N-9	UNSHREDDABLE SHEAR	UNSHREDDABLE HMML.	HARD TO SHRED SHEAR	HARD TO SHRED HMML.
GROSS WEIGHT, LBS.	35600				
TARE WEIGHT, LBS.	32920				
NET WEIGHT, LBS.	2680				
VOLUME, CU.FT.	1080				
USAGE	0.70				
NET VOLUME, CU.FT.	756				
DENSITY, LB./CU.FT	3.5				
PAPER	592	0	0	0	0
PLASTIC					
Light	20	0	0	0	0
Heavy	9	0	0	0	0
Other	8	0	0	0	0
RUBBER					
Tires					
Other					
CARDBOARD	1650	0	0	0	0
TEXTILES					
WOOD					
Pallets	210	0	210	0	0
Other					
MISC. ORGANICS	30	0	0	0	0
GLASS	125	0	0	0	0
INERTS/CERAMICS					
FERROUS					
Cable/Strapping	6	0	0	0	0
Other	11	0	9	0	0
NONFERROUS					
Cable					
Other	10	0	0	0	0
OTHER/SPECIAL					
Aerosol Can					
Paint					
Solvents	9	0	0	0	0
Oil					
Insulation					
TOTAL	2680	0	219	0	0
PERCENT		0.00	8.17	0.00	0.00

DATE			22-Aug		
BASE ID		BLDG	67		
	SAMPLE	UNSHREDDABLE		HARD TO SHRED	
	N-10	SHEAR	HMML.	SHEAR	HMML.
GROSS WEIGHT, LBS.	35440				
TARE WEIGHT, LBS.	33100				
NET WEIGHT, LBS.	2340				
VOLUME, CU.FT.	1080				
USAGE	0.70				
NET VOLUME, CU.FT.	756				
DENSITY, LB./CU.FT	3.1				
PAPER	220	0	0	0	0
PLASTIC					
Light	90	0	0	0	0
Heavy	12	0	0	0	0
Other	9	0	0	0	0
RUBBER					
Tires					
Other	9	0	0	0	0
CARDBOARD	1300	0	190	0	130
TEXTILES					
WOOD					
Pallets	110	0	0	0	70
Other	550	0	460	0	0
MISC. ORGANICS					
GLASS	1	0	0	0	0
INERTS/CERAMICS	8	0	0	0	0
FERROUS					
Cable/Strapping	11	0	0	0	0
Other	16	0	0	0	0
NONFERROUS					
Cable					
Other	3	0	0	0	0
OTHER/SPECIAL					
Aerosol Can					
Paint	1	0	0	0	0
Solvents					
Oil					
Insulation					
TOTAL	2340	0	650	0	200
PERCENT		0.00	27.78	0.00	8.55

Appendix D

NAVY WASTE SAMPLES
INDIVIDUAL, RAW DATA SHEETS

SAMPLE COMPOSITION

Component	Weight (pounds)	Comments	Photographed Yes	Photographed No
Paper[o]	6,503*	Large quantities of computer print-out paper and out-dated government documents	✓	
Plastic[o]				
Light (film)	80	mostly clean bags	✓	
Heavy (molded)	50	container rings, containers; and miscellaneous	✓	
Other (foam, etc)	60	styrofoam packaging, plates, etc	✓	
Rubber[o]				
Tires	—	None		
Other rubber	—	None		
Cardboard	420	mostly small & medium size boxes	✓	
Textiles[o]	15	Printer cloth	✓	
Wood[o]				
Pallets	25	small box pallet	✓	
Other wood	20	crate, small container, scrap	✓	
Misc. organics[o]	100	mainly foodstuff	✓	
Glass	20	Bottles, flourescent bulbs	✓	
Inerts/ceramics	2	Pottery		✓
Ferrous metals[o]				
Cable/strapping	5	strapping	✓	
Other ferrous	15	Cans, miscellaneous	✓	
Nonferrous metals[o]				
Cable	—	None		
Other nonferrous	10	Beverage containers, foil, misc.	✓	
Other/special wastes[o]				
oil	15	~2 gallons in plastic bags containing metal filings	✓	

[x] Where x identifies the number of unshreddable or difficult-to-shred items, described on separate sheet(s).

* Determined by difference

3-14-84

SAMPLE COMPOSITION

Component	Weight (pounds)	Comments	Photographed Yes	Photographed No
Paper[ ]	20#	Trace amount		✓
Plastic[ ]				
Light (film)	1,380 #	Largely packaging type	✓	
Heavy (molded)	90.0 #	Mostly strapping	✓	
Other (foam, etc)	30#		✓	
Rubber[ ]				
Tires	—	None		✓
Other rubber molding	90#	molded strips	✓	
Cardboard 1,956	Balance	Large Cardboard Boxes	✓	
Textiles[ ] Rope	15#	Rope / Cloth	✓	
Wood[ ]				
Pallets Mixed	820#	Pallets, Tree branches	✓	
Other wood		Misc. Scrap wood	✓	
Misc. organics[ ] Leaves	640#	Sweeping Compound Bags of Leaves	✓	
Glass	60#	Bottles, florescent light tubes	✓	
Inerts/ceramics	1#	Bowl	✓	
Ferrous metals[ ]				
Cable/strapping	20#	Several Pieces of Strapping	✓	
Other ferrous	25#	Food Cans, 1 gallon Containers	✓	
Nonferrous metals[ ]				
Cable	3#	Alumn. Angle	✓	
Other nonferrous	10#	Alumn cans	✓	
Other/special wastes[ ]				
None	—			✓

[x] Where x identifies the number of unshreddable or difficult-to-shred items, described on separate sheet(s).

3-21-84

SAMPLE COMPOSITION

Component	Weight (pounds)	Comments	Photographed Yes	Photographed No
Paper[ ]	3#	Mixture of paper products	✓	
Plastic[ ]				
Light (film)	90#	sm. pkg. bags, etc.	✓	
Heavy (molded)	5#		✓	
Other (foam, etc)	4#	packaging material	✓	
Rubber[ ]				
Tires	—	None		✓
Other rubber	60#	Foam Rubber	✓	
Cardboard	2173		✓	
Textiles[ ]	175#	Painters Cloth; Rope	✓	
Wood[ ]				
Pallets	220#	Pallets	✓	
Other wood	3#			✓
Misc. organics[ ]	30#	Linoleum		✓
Glass	Trace	1 Bottle		✓
Inerts/ceramics	110#	Pipe Insulation	✓	
Ferrous metals[ ]				
Cable/strapping	3#	Metal Studs, Lids	✓	
Other ferrous	20#			✓
Nonferrous metals[ ]				
Cable	None			✓
Other nonferrous	4#	Cans, pieces of Alum. sheet		✓
Other/special wastes[ ]				
Insulation	40#	Spun glass Insulation	✓	

[x] Where x identifies the number of unshreddable or difficult-to-shred items, described on separate sheet(s).

5-16-84

SAMPLE COMPOSITION

Component	Weight (pounds)	Comments	Photographed Yes	Photographed No
Paper[4]	2315	Computor print outs, Envelopes Paper cups, Rolls of carbon Paper	✓	-
Plastic[4]		Bubble pak plastic, plastic bag Heavy Plastic Film	✓	
Light (film)	30			
Heavy (molded)	—	NONE		
Rubber[4]	2	Rubber gloves, O-Rings	✓	
Tires	—	NONE		
Other rubber	—			
Cardboard	1880	LARGE BOXES,	✓	
Textiles[4]	65	Nylon WEBBING, Rope	✓	
Wood[4]		HEAVY OAK Pallets	✓	
Pallets	450			
Other wood	—	—		
Misc. organics[ ]	—	—		
Glass	—	None		
Inerts/ceramics	—	NONE		
Ferrous metals[4]				
Cable				
Other ferrous	12	Strapping MATERIAL Small Piece Galv. Pipe	✓	
Nonferrous metals[ ]				
Cable	—			
Other nonferrous	1	Alumn Beverage CANS	✓	
Other/special wastes[4]		Flamable Liquid contents	✓	
AEROSOL CAN	1			
PAINT	3	1 GAL. PAINT CAN Full of PAINT	✓	

[x] Where x identifies the number of unshreddable or difficult-to shred items, described on separate sheet(s).

5-23-84

SAMPLE COMPOSITION

Component	Weight (pounds)	Comments	Photographed Yes	Photographed No
Paper [4]	1056	Cases of new computor paper, forms, old manuals, packaging paper	✓	
Plastic [4]				
Light (film)	48	Bubble Pak, film plastic packaging plastic	✓	
Heavy (molded)	1	Plastic office tray	✓	
Rubber [4]				
Tires		None		✓
Other rubber	16	Foam rubber	✓	
Cardboard	1200	Boxes, shipping inserts	✓	
Textiles [4]	1.5	Cotton cord old shirt used as rag	✓	
Wood [4]				
Pallets	385	Pallets, misc. pieces of pallets	✓	
Other wood	83	Shipping crates	✓	
Misc. organics [ ]	2	Food scrapes		✓
Glass	1.5	Bottle - 10"x18" plate glass	✓	
Inerts/ceramics	15	Dirt -		✓
Ferrous metals [ ]				
Cable -	29	Strapping	✓	
Other ferrous	37	1"x4 ft Re-Rod 3/4x10 ft pipe 1/4"x3 ft rod - s/ew spare part	✓	
Nonferrous metals [ ]				
~~Cable~~ Cans	3	Alumn cans	✓	
Other nonferrous	21	Alumn blocks (spare parts) split sleeves	✓	
Other/special wastes [4]				
Aero-sol can	1	Primer spray can (Flammable)	✓	

[x] Where x identifies the number of unshreddable or difficult to-shred items, described on separate sheet(s).

5-30-84

SAMPLE COMPOSITION

Component	Weight (pounds)	Comments	Photographed Yes	Photographed No
Paper [✓]	1450	MANUALS, PAPER TOWELS WRAPPING	✓	-
Plastic [✓]				
Light (film)	80	GARBAGE BAGS, PACKAGING MATERIAL	✓	
Heavy (molded)	40	PLASTIC TUBES, REELS, CAN COVERS	✓	
Rubber [ ]				
Tires		NONE		
Other rubber	470	RUBBER MATTING, HOSE, TUBING	✓	
Cardboard	800	BOXES	✓	
Textiles [✓]	390	RAGS, OLD UNIFORMS, ROPE	✓	
Wood [✓]				
Pallets				
Other wood	30	SMALL BOXES	✓	
Misc. organics [✓]	5500	FOOD WASTE	✓	
Glass	40	FLUORESCENT TUBES, BOTTLES	✓	
Inerts/ceramics	60	TOILET STOOL	✓	
Ferrous metals [✓]				
Cable				
Other ferrous	90	CANS, STEPS, BOLTS, ANGLE IRON, METAL FLANGES	✓	
Nonferrous metals [ ]				
Cable	29	COVERED COPPER WIRE	✓	
Other nonferrous	76	ALUMINUM CANS, STEPS BRASS BOLTS, LOCKS	✓	
Other/special wastes [ ]				
LIQUID	5	CAN OF ALCOHOL-FULL HIGHLY FLAMMABLE AEROSOL PAINT CANS	✓	

[x] Where x identifies the number of unshreddable or difficult-to shred items, described on separate sheet(s).

38

7-11-84

SAMPLE COMPOSITION

Component	Weight (pounds)	Comments	Photographed Yes	No
Paper[ ]	790	Computer paper handtowels. Forms	✓	
Plastic[ ]				
Light (film)	90	Bags	✓	
Heavy (molded)	30	Buckets, Face of Radio, Bottles	✓	
Other (foam, etc)				
Rubber[ ]				
Tires	no			✓
Other rubber	20	hose, Tube, Foam rubber	✓	
Cardboard	1100	Boxes	✓	
Textiles[ ]	195	Rags, Rope	✓	
Wood[ ]				
Pallets	70	small pallets	✓	
Other wood	1400	misc. wood Plywood, 2x4", 2x6"	✓	
Misc. organics[ ]	~~5600~~ 4453	Food waste	✓	
Glass	78	Bottles, Fiberglass Insulation.	✓	
Inerts/ceramics	no			
Ferrous metals[ ]				
Cable/strapping	9	steel Cable	✓	
Other ferrous	105	Tin Cans strapping, Rods Angle Iron, Pins. large Steel Drums	✓	
Nonferrous metals[ ]				
Cable				
Other nonferrous	100 lbs	Alumn. Cans, Brass Fittings, Alumn. Angles, Coax wire	✓	
Other/special wastes[ ]				
______	60 lbs	Insulation	✓	
______				

[x] Where x identifies the number of unshreddable or difficult-to-shred items, described on separate sheet(s).

7-25-84

SAMPLE COMPOSITION

Component	Weight (pounds)	Comments	Photographed Yes	Photographed No
Paper [✓]	190	towels, Bags, forms, Light bulb cases	✓	
Plastic [✓]				
Light (film)	128	plastic Bags, packing materials, Plastic sheeting	✓	
Heavy (molded)				
Other (foam, etc)	6	foam shipping material	✓	
Rubber [✓]				
Tires		n/A		
Other rubber		4x4x2' large boxe inserts		
Cardboard	1494		✓	
Textiles [✓]	4	Burlap Bag, thin ~~Rope, Dust pig head~~	✓	
Wood [✓]		large and small pallets		
Pallets	670			
Other wood	650	2x4"x16" 2x4"x8' 1x6"x2' short 2x4"x3	✓	
Misc. organics [ ]				
Glass	5	light bulbs, bottles, Jar	✓	
Inerts/ceramics	70	insulation for pipe	✓	
Ferrous metals [ ]				
Cable/strapping	20	Black metal strapping	✓	
Other ferrous			✓	
Nonferrous metals [ ]				
Cable				
Other nonferrous	1	alum	✓	
Other/special wastes [ ]				
Hair Spray	1	~~Aerosol can~~ hair spray (Flamable)	✓	

[x] Where x identifies the number of unshreddable or difficult-to-shred items, described on separate sheet(s).

8-15-84

SAMPLE COMPOSITION

Component	Weight (pounds)	Comments	Photographed Yes	No
Paper [4]	59.2	Computor paper, Invoice, Misc.	✓	
Plastic [ ]				
Light (film)	20	Plastic bags, Large Plastic sheets	✓	
Heavy (molded)	9	3/4" Plastic Pipe TOILET SEAT.		
Other (foam, etc)	8	Foam for shipping	✓	
Rubber [ ]				
Tires		none		
Other rubber		none		
Cardboard	1650	Flattened Cardbd. boxes	✓	
Textiles [4]		CORD, RAGS	✓	
Wood [ ]				
Pallets	210	3' x 3' Hardwood pallets		
Other wood				
Misc. organics [4]	30	Food Waste	✓	
Glass ✓	125	Fluorescent Bulbs, Glass Bottles	✓	
Inerts/ceramics		none		
Ferrous metals [ ]				
Cable/strapping	6	Band Material	✓	
Other ferrous	11	Paint Pans and Small pieces Moctar	✓	
Nonferrous metals [ ]				
Cable				
Other nonferrous	10	Beverage Cans	✓	
Other/special wastes [ ]				
Container	9	1gal. Paint Thinner	✓	

[x] Where x identifies the number of unshreddable or difficult-to-shred items, described on separate sheet(s).

SAMPLE COMPOSITION 8-22-84

Component	Weight (pounds)	Comments	Photographic Yes	Photographic No
Paper [4]	220	misc. forms, Brown paper		✓
Plastic [4]		Bags, sheets, Bubble		
Light (film)	90	packaging material	✓	
Heavy (molded)	12	molded box packing	✓	
Other (foam, etc)	9	Sponge packing material	✓	
Rubber [ ]				
Tires		None		
Other rubber	9	Sponge packing	✓	
Cardboard	~~1400~~ 1300	large cardboard boxes	✓	
Textiles [ ]		None		
Wood [ ]				
Pallets	110	Small Pallets	✓	
Other wood	550	Packing boxes 18"x) FT	✓	
Misc. organics [ ]		None		
Glass	1	glass beverage bottle	✓	
Inerts/ceramics	8	Dirt	✓	
Ferrous metals [ ]				
Cable/strapping	11	strapping material	✓	
Other ferrous	16	Angle Iron	✓	
Nonferrous metals [ ]				
Cable	1	½" Copper pipe	✓	
Other nonferrous	2	Beverage Cans	✓	
Other/special wastes [ ]				
Arcrylic lacquer Cans	1	paint can	✓	

[x] Where x identifies the number of unshreddable or difficult-to shred items, described on separate sheet(s).

Appendix E

DATA SHEETS:
SHREDDER POWER, TONNAGE AND LABOR

DATE	MILL #1	MILL #3	MILL #1	MILL #2	MILL #3	MILL #1			MILL #2			MILL #3		
	POWER (kwh)		TONNAGE (tons)			****** LABOR ********			******* LABOR ********			******* LABOR ********		
	-----	-----	-----	-----	-----	Co's	Maint	Other	Co's	Maint	Other	Co's	Maint	Other
02-Jan-84														
03-Jan-84				114	144									
04-Jan-84				51	60									
05-Jan-84			327											
06-Jan-84			273											
07-Jan-84														
08-Jan-84														
09-Jan-84			338											
10-Jan-84			333											
11-Jan-84			78											
12-Jan-84			279											
13-Jan-84			285											
14-Jan-84														
15-Jan-84														
16-Jan-84														
17-Jan-84			427	76	79									
18-Jan-84			141											
19-Jan-84			379	59	68									
20-Jan-84			220	68	61									
21-Jan-84														
22-Jan-84														
23-Jan-84			344	51	91									
24-Jan-84			368	57	59									
25-Jan-84			198	35	25									
26-Jan-84			390	59	65									
27-Jan-84			325	58	62									
28-Jan-84														
29-Jan-84														
30-Jan-84			414	153	140									
31-Jan-84			381	151	188									
01-Feb-84			90	16	16									
02-Feb-84			72	105	114									
03-Feb-84				77	65									
04-Feb-84														
05-Feb-84														
06-Feb-84				77	82									
07-Feb-84				51	100									
08-Feb-84			20	10	12									
09-Feb-84			271	59	26									
10-Feb-84			259	79	77									
11-Feb-84														
12-Feb-84														
13-Feb-84			378	132	142									
14-Feb-84			395	149	146									
15-Feb-84			81											
16-Feb-84			279	75	76									
17-Feb-84			254	88	89									
18-Feb-84														
19-Feb-84														
20-Feb-84			225	68	68									
21-Feb-84			409	98	93									
22-Feb-84			133	8	8									

DATE	MILL #1 POWER (kwh)	MILL #3 POWER (kwh)	MILL #1 TONNAGE (tons)	MILL #2 TONNAGE (tons)	MILL #3 TONNAGE (tons)	MILL #1 LABOR Op's	MILL #1 LABOR Maint	MILL #1 LABOR Other	MILL #2 LABOR Op's	MILL #2 LABOR Maint	MILL #2 LABOR Other	MILL #3 LABOR Op's	MILL #3 LABOR Maint	MILL #3 LABOR Other
	-----	-----	-----	-----	-----									
23-Feb-84			415	56	115									
24-Feb-84			338	59	54									
25-Feb-84														
26-Feb-84														
27-Feb-84			452	133	117									
28-Feb-84			370	141	129									
29-Feb-84			142	12	10									
01-Mar-84			263	72	67	12	0.8	1	11	0.6	1	11	0.6	1
02-Mar-84			274	95	95	12	0.8	1	11	0.6	1	11	0.6	1
03-Mar-84														
04-Mar-84														
05-Mar-84			419	128	107	12	0.8	1	11	0.6	1	11	0.6	1
06-Mar-84			406	107	116	12	0.8	1	11	0.6	1	11	0.6	1
07-Mar-84			184	29	29	8	0.8	1	5	1.6	1	6	1.6	1
08-Mar-84			334	41	96	12	0.8	1	11	0.6	1	11	0.6	1
09-Mar-84			315	100	96	12	0.8	1	11	0.6	1	11	0.6	1
10-Mar-84														
11-Mar-84														
12-Mar-84			148	99	101	12	0.8	1	11	0.6	1	11	0.6	1
13-Mar-84			381	98	87	12	0.8	1	11	0.6	1	11	0.6	1
14-Mar-84			75			8	0.8	2	0	0	0	0	1	0
15-Mar-84			313	77	66	12	0.8	1	11	0.6	1	11	0.6	1
16-Mar-84			375	92	81	12	0.8	1	11	0.6	1	11	0.6	1
17-Mar-84														
18-Mar-84														
19-Mar-84			352	129	123	12	0.8	1	11	0.6	1	11	0.6	1
20-Mar-84			375	125	122	12	0.5	1	11	0.5	1	11	1	1
21-Mar-84			181	43	41	7	0.5	1	7	2	1	7	2.5	1
22-Mar-84			325	87	97	12	0.8	1	11	0.6	1	11	0.6	1
23-Mar-84	1200	400	352	85	82	12	0.8	1	11	0.6	1	11	0.6	1
24-Mar-84														
25-Mar-84														
26-Mar-84	1000	400	422	103	104	11	0.8	1	10	0.6	1	13	0.6	1
27-Mar-84	1200	600	457	130	100	11	0.8	1	10.5	1.6	1	10.5	1.6	1
28-Mar-84	600	200	145	39	25	8	0.8	1	7	0.6	1	7	0.6	1
29-Mar-84	1200	800	375	56	71	12	0.8	1	10.5	1.6	1	10.5	0.6	1
30-Mar-84	1200	600	379	83	79	12	0.8	1	11	0.6	1	11	0.6	1
31-Mar-84														
01-Apr-84														
02-Apr-84	1000	1200	315	108	109	10.5	2.3	1	11	0.6	1	11	0.5	1
03-Apr-84	1200	600	439	106	105	12	0.8	1	11	0.6	1	11	0.6	1
04-Apr-84	800	400	246	50	49	8	0.8	1	7	0.6	1	6	0.6	1
05-Apr-84	1000	400	315	51	50	12	0.8	1	11	0.6	1	11	0.6	1
06-Apr-84	1200	600	262	51	50	12	0.8	1	12	1.6	1	11	0.6	1
07-Apr-84														
08-Apr-84														
09-Apr-84														
10-Apr-84														
11-Apr-84														
12-Apr-84														
13-Apr-84														
14-Apr-84														

DATE	MILL #1 POWER (kwh)	MILL #3 POWER (kwh)	MILL #1 TONNAGE (tons)	MILL #2 TONNAGE (tons)	MILL #3 TONNAGE (tons)	MILL #1 LABOR Op's	MILL #1 LABOR Maint	MILL #1 LABOR Other	MILL #2 LABOR Op's	MILL #2 LABOR Maint	MILL #2 LABOR Other	MILL #3 LABOR Op's	MILL #3 LABOR Maint	MILL #3 LABOR Other
15-Apr-84														
16-Apr-84	tires		24											
17-Apr-84			31											
18-Apr-84			37											
19-Apr-84			333	52	52									
20-Apr-84														
21-Apr-84														
22-Apr-84														
23-Apr-84	1000	600	423	82	82	12	0.8	1	11	0.6	1	11	0.6	1
24-Apr-84	1000	800	438	110	110	12	0.8	1	11	0.6	1	11	0.6	1
25-Apr-84	600	400	236	34	34	8	0.8	1	7	0.6	1	7	0.6	1
26-Apr-84	1000	600	379	59	58	12	0.8	1	11	0.6	1	11	0.6	1
27-Apr-84	1200	600	362	67	67	12	0.8	1	11	0.6	1	11	0.6	1
28-Apr-84														
29-Apr-84														
30-Apr-84	1000	800	386	124	123	12	0.8	1	11	0.6	1	10.5	1.1	1
01-May-84	1000	800	366	92	92	12	0.4	1	11	0.3	1	11	0.8	1
02-May-84	600	400	197	19	18	8	0.4	1	7	0.3	1	7	0.3	1
03-May-84	1200	200	360	42	41	12	0.4	1	11	0.3	1	11	0.3	1
04-May-84	1200	800	365	52	49	12	0.4	1	11	0.3	1	11	0.3	1
05-May-84														
06-May-84														
07-May-84	800	600	441	66	65	12	0.3	1	11	0.3	1	11	0.3	1
08-May-84	1000	800	400	123	122	12	0.4	1	11	0.3	1	11	0.3	1
09-May-84	1000	500	253	31	31	8	0.8	1	6	2.6	1	7	0.6	1
10-May-84	600	400	311	53	52	12	0.8	1	11	0.6	1	10	2.6	1
11-May-84	1200	1000	369	75	75	12	0.8	1	11	0.6	1	11	0.6	1
12-May-84														
13-May-84														
14-May-84	1000	800	347	91	92	12	0.8	1	11	0.6	1	11	0.6	1
15-May-84	1200	600	415	66	65	12	0.8	1	9	0.6	1	11	0.6	1
16-May-84	600	400	198	21	20	8	0.8	1	7	0.6	1	7	0.6	1
17-May-84	1200	800	246	68	69	12	0.8	1	11	0.6	1	11	0.6	1
18-May-84	1000	600	343	85	85	12	0.8	1	11	0.6	1	11	0.6	1
19-May-84														
20-May-84														
21-May-84	1000	800	327	80	82	12	0.8	1	11	0.6	1	11	0.6	1
22-May-84	1000	1000	389	102	101	12	0.6	1	11	0.6	1	11	0.6	1
23-May-84	800	200	183	15	15	8	0.8	1	7	0.6	1	7	0.6	1
24-May-84	1000	800	282	63	63	12	0.8	1	11	0.6	1	11	0.6	1
25-May-84	1000	600	298	91	92	12	0.8	1	11	0.6	1	11	0.6	1
26-May-84														
27-May-84														
28-May-84	1000	600	272	45	44	12	0.8	1	11	0.6	1	11	0.6	1
29-May-84	1000	200	362	66	66	12	0.6	1	11	0.5	1	11	0.6	1
30-May-84	800	600	215	23	22	6	0.8	1	7	0.6	1	7	0.6	1
31-May-84	1200	400	341	73	[illegible]	12	0.6	1	11	0.6	1	11	0.6	1
01-Jun-84	1000	1000	413	107	106	12	0.8	1	11	0.6	1	11	0.6	1
02-Jun-84														
03-Jun-84														
04-Jun-84	1000	800	384	[illegible]	121	12	0.4	1	11	0.3	1	11	0.3	1
05-Jun-84	1000	600	361	59	56	12	0.4	1	11	0.3	1	11	0.3	1

DATE	MILL #1 POWER (kwh)	MILL #3 POWER (kwh)	MILL #1 TONNAGE (tons)	MILL #2 TONNAGE (tons)	MILL #3 TONNAGE (tons)	MILL #1 ****** LABOR ******** Op's	MILL #1 Maint	MILL #1 Other	MILL #2 ******* LABOR ******** Op's	MILL #2 Maint	MILL #2 Other	MILL #3 ******* LABOR ******** Op's	MILL #3 Maint	MILL #3 Other
06-Jun-84	600	400	169	29	28	8	0.8	1	7	0.6	1	7	0.6	1
07-Jun-84	1000	600	292	61	60	12	0.8	1	10.3	0.6	1	10.3	0.6	1
08-Jun-84	1200	800	352	75	75	12	0.8	1	11	0.6	1	11	0.6	1
09-Jun-84														
10-Jun-84														
11-Jun-84	1000	800	360	90	89	12	0.8	1	11	0.6	1	11	0.6	1
12-Jun-84	1200	600	355	99	98	12	0.8	1	11	0.6	1	11	0.6	1
13-Jun-84	800	400	150	20	20	8	0.8	1	7	0.6	1	7	0.6	1
14-Jun-84	1000	200	285	40	35	12	0.8	1	11	0.6	1	11	0.6	1
15-Jun-84	200	600		23	22	12	0.8	1	11	0.6	1	11	0.6	1
16-Jun-84														
17-Jun-84														
18-Jun-84		800		85	84									
19-Jun-84		800		83	82									
20-Jun-84		200		19	18									
21-Jun-84		600		61	61									
22-Jun-84		1000		82	82									
23-Jun-84														
24-Jun-84														
25-Jun-84	400	600	162	90	90	12	0.8	1	11	0.6	1	11	0.6	1
26-Jun-84	1000	800	404	89	88	12	0.8	1	11	0.6	1	11	0.6	1
27-Jun-84	600	0	102			8	0.8	1	7	0.6	1	7	0.6	1
28-Jun-84	1000	600	310	64	63	12	0.8	1	11	0.6	1	11	0.6	1
29-Jun-84	800	1000	314	88	87	12	0.8	1	11	0.6	1	11	0.6	1
30-Jun-84														
01-Jul-84														
02-Jul-84	1000	600	413	70	69	12	0.4	1	11	0.3	1	11	0.3	1
03-Jul-84	1200	600	468	109	106	12	0.4	1	11	0.3	1	11	0.3	1
04-Jul-84														
05-Jul-84	1000	600	347	103	102	12	0.4	1	11	0.3	1	11	0.3	1
06-Jul-84	1000	800	382	74	74	12	0.4	1	11	0.3	1	11	0.3	1
07-Jul-84														
08-Jul-84														
09-Jul-84	1000	400	393	81	81	12	0.8	1	11	0.6	1	11	0.6	1
10-Jul-84	1000	800	427	117	117	12	0.6	1	11	0.6	1	11	0.6	1
11-Jul-84	400	200	88	25	25	12	0.8	1	11	0.6	1	11	0.6	1
12-Jul-84	600	600	259	72	72	12	0.8	1	11	0.6	1	11	0.6	1
13-Jul-84	1200	400	309	27	26	12	0.8	1	11	0.6	1	11	0.6	1
14-Jul-84														
15-Jul-84														
16-Jul-84	1000	0	384			12	0.8	1	11	0.6	1	11	0.6	1
17-Jul-84	1000	0	462			12	0.8	1	11	0.6	1	11	0.6	1
18-Jul-84	600	0	226	0	0	8	0.8	1	7	0.6	1	7	0.6	1
19-Jul-84	1000	600	352	57	57	12	0.6	1	11	0.6	1	11	0.6	1
20-Jul-84	1000	900	392	65	65	12	0.8	1	11	0.6	1	11	0.6	1
21-Jul-84														
22-Jul-84														
23-Jul-84	1000	600	432	94	93	12	0.8	1	11	0.6	1	11	0.6	1
24-Jul-84	600	800	243	102	102	12	0.6	1	11	0.6	1	11	0.6	1
25-Jul-84	500	200	178	19	19	12	0.8	1	11	0.6	1	11	0.6	1
26-Jul-84	800	600	292	98	97	8	0.8	1	7	0.6	1	7	0.6	1
27-Jul-84	1000	800	332	103	102	12	0.8	1	11	0.5	1	11	0.6	1

DATE	MILL #1 POWER (kwh)	MILL #3 POWER (kwh)	MILL #1 TONNAGE (tons)	MILL #2 TONNAGE (tons)	MILL #3 TONNAGE (tons)	MILL #1 LABOR Op's	MILL #1 LABOR Maint	MILL #1 LABOR Other	MILL #2 LABOR Op's	MILL #2 LABOR Maint	MILL #2 LABOR Other	MILL #3 LABOR Op's	MILL #3 LABOR Maint	MILL #3 LABOR Other
28-Jul-84														
29-Jul-84														
30-Jul-84	1200	600	372	92	92	12	0.8	1	11	0.6	1	11	0.6	1
31-Jul-84	800	800	364	122	121	12	0.8	1	11	0.6	1	11	0.6	1
01-Aug-84	600	200	185	29	28	8	0.8	1	7	0.6	1	7	0.6	1
02-Aug-84	1000	800	310	79	78	12	0.8	1	11	0.6	1	11	0.6	1
03-Aug-84	1000	1000	298	101	101	12	0.8	1	11	0.6	1	11	0.6	1
04-Aug-84														
05-Aug-84														
06-Aug-84	1000	800	348	116	115	12	0.4	1	11	0.3	1	11	0.3	1
07-Aug-84	1000	800	426	119	119	12	0.8	1	11	0.6	1	11	0.6	1
08-Aug-84	500	0	108			8	0.8	1	7	0.6	1	7	0.6	1
09-Aug-84	1000	600	324	81	81	12	0.8	1	11	0.6	1	11	0.6	1
10-Aug-84	800	800	305	93	92	12	0.8	1	11	0.6	1	11	0.6	1
11-Aug-84														
12-Aug-84														
13-Aug-84	800	800	316	110	110	12	0.8	1	11	0.6	1	11	0.6	1
14-Aug-84	1200	800	370	109	108	12	0.8	1	11	0.6	1	11	0.6	1
15-Aug-84	600	200	96	23	23	8	0.8	1	7	0.6	1	7	0.6	1
16-Aug-84	1200	600	306	72	71	12	0.8	1	11	0.6	1	11	0.6	1
17-Aug-84	1000	400	329	69	68	12	0.8	1	11	0.6	1	11	0.6	1
18-Aug-84														
19-Aug-84														
20-Aug-84	1200	600	386	105	105	12	0.8	1	11	0.6	1	11	0.6	1
21-Aug-84	1200	800	324	148	147	12	0.8	1	11	0.6	1	11	0.6	1
22-Aug-84	400	200	102	19	19	8	0.8	1	11	0.6	1	11	0.6	1
23-Aug-84	1200	600	303	63	62	12	0.8	1	11	0.6	1	11	0.6	1
24-Aug-84	800	800	328	84	83	12	0.8	1	11	0.6	1	11	0.6	1
25-Aug-84														
26-Aug-84														
27-Aug-84	1200	800	406	94	93	12	0.8	1	11	0.6	1	11	0.6	1
28-Aug-84	1000	600	388	99	98	12	0.8	1	11	0.6	1	11	0.6	1
29-Aug-84	800	400	116	62	62	8	0.8	1	7	0.6	1	7	0.6	1
30-Aug-84	1000	600	289	73	72	12	0.8	1	11	0.6	1	11	0.6	1
31-Aug-84	1000	400	283	91	90	12	0.8	1	11	0.6	1	11	0.6	1
01-Sep-84														
02-Sep-84														
03-Sep-84	1000	1600												
04-Sep-84														
05-Sep-84														
06-Sep-84														
07-Sep-84														
08-Sep-84														
09-Sep-84														
10-Sep-84			17	84	63									
11-Sep-84			74	56	55									
12-Sep-84			78											
13-Sep-84	1200	400	343	39	39	12	0.8	1	11	0.6	1	11	0.6	1
14-Sep-84	1000	600	360	64	63	12	0.8	1	11	0.6	1	11	0.6	1
15-Sep-84			80											
16-Sep-84														
17-Sep-84	1000	400	420	51	52	12	0.8	1	11	0.6	1	11	0.6	1

DATE	MILL #1 POWER (kwh)	MILL #3 POWER (kwh)	MILL #1 TONNAGE (tons)	MILL #2 TONNAGE (tons)	MILL #3 TONNAGE (tons)	MILL #1 ****** LABOR ******** Op's	MILL #1 Maint	MILL #1 Other	MILL #2 ******* LABOR ******** Op's	MILL #2 Maint	MILL #2 Other	MILL #3 ******* LABOR ******** Op's	MILL #3 Maint	MILL #3 Other
	-----	-----	-----	-----	-----									
18-Sep-84	1000	800	359	103	103	12	0.8	1	11	0.6	1	11	0.6	
19-Sep-84	0	0	63	16	16	8	0.8	1	7	0.6	1	7	0.5	
20-Sep-84			298	50	50									
DAYS	107.00	111.00	165.00	157.00	157.00	121.00	121.00	121.00	121.00	121.00	121.00	121.00	121.00	121.00
WEEKS	21.4	22.2	33	31.4	31.4	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2
AVERAGE	934.58	598.20	295.21	75.65	74.92	11.24	0.82	1.01	10.18	0.64	0.99	10.22	0.63	0.99
MAX VALUE	1200.00	1600.00	428.00	153.00	147.00	12.00	7.90	2.00	11.90	2.60	1.00	13.00	2.60	1.00
VARIANCE	62472.2	75723.9	12697.1	1101.74	1087.51	2.45447	0.446201	0.008264	3.212334	0.127579	0.008264	3.255867	0.095505	0.008264
STD.DEV.	249.94	276.99	112.68	33.19	32.98	1.57	0.67	0.09	1.79	0.36	0.09	1.81	0.31	0.09
DEV/AVG	0.267	0.463	0.382	0.439	0.440	0.139	0.813	0.090	0.176	0.558	0.092	0.177	0.492	0.092
SUM	100002	66400	48709	11877	11763	1359.5	99.4	122	1232.3	77.4	120	1236.8	76.4	120

Appendix F

DATA SHEETS:
SHREDDER OPERATING HOURS

DATE	************* MILL #1 *************					************* MILL #2 *************					************* MILL #3 *************				
	Running Time		-------Downtime -------			Running Time		-------Downtime -------			Running Time		-------Downtime -------		
	Process	Idle	Blockage	Repairs	No-Fault	Process	Idle	Blockage	Repairs	No-Fault	Process	Idle	Blockage	Repairs	No-Fault
02-Jan-84															
03-Jan-84	0	0	0	9	0	5.2	0.1	0	0.5	3.2	6.6	1	0.4	0.5	0.5
04-Jan-84	0	0	0	6	0	3.5	1.2	0	0	1.3	4.2	0.8	0	0.5	0.5
05-Jan-84	4.9	3.6	0	0	0.5	0.9	0	0	8.1	0	1.2	0	0	7.8	0
06-Jan-84	4.7	3.8	0	0	0.5	0	0	0	9	0	0	0	0	9	0
07-Jan-84															
08-Jan-84															
09-Jan-84	5.5	3.2	0	0	0.3	0	0	0	9	0	0	0	0	9	0
10-Jan-84	4.4	4.2	0	0	0.4	0	0	0	9	0	0	0	0	9	0
11-Jan-84	1.3	4	0	0	0.7	0	1.5	0	4.5	0	0	0	0	6	0
12-Jan-84	5	3	0	0.3	0.7	0	0	0	9	0	0	1	0	8	0
13-Jan-84	5.3	3.2	0	0	0.5	0	0	0	9	0	0	0	0	9	0
14-Jan-84															
15-Jan-84															
16-Jan-84															
17-Jan-84	5.6	2.7	0	0.3	0.4	3.3	2.2	0	0	3.5	3.4	2.1	0	0	3.5
18-Jan-84	3.1	2.2	0	0	0.7	0	0	0	0	6	0	0	0	0	6
19-Jan-84	5.5	3.1	0	0	0.4	3.2	1.8	0	0	4	3.2	1.6	0	0	4.2
20-Jan-84	5.3	2.9	0	0	0.8	4.5	0.9	0	0	3.6	4	0.7	0	0	4.3
21-Jan-84															
22-Jan-84															
23-Jan-84	5	2.9	0	0	1.1	4	1.4	0	0.5	3.1	4	1.2	0	0.5	3.3
24-Jan-84	5.9	2.8	0	0	0.3	2.4	2.1	1	0	3.5	2.5	2.9	0.1	0	3.5
25-Jan-84	3.9	1.5	0	0	0.6	2.4	1.5	0	0	2.1	1.7	2.2	0	0	2.1
26-Jan-84	5.6	2.9	0	0	0.5	2.6	1.8	0.2	0	4.4	2.9	1.7	0	0	4.4
27-Jan-84	4.4	4.1	0	0	0.5	3.4	1.4	0	0	4.2	3.6	0.7	0.5	0	4.2
28-Jan-84															
29-Jan-84															
30-Jan-84	5.9	2.9	0	0	0.2	6.3	1.8	0	0	0.9	5.8	2.4	0.1	0	0.7
31-Jan-84	5.3	3.4	0	0	0.3	6.3	1.8	0	0	0.9	4.5	1.4	0.1	0	3
01-Feb-84	1.9	2.9	0	0	1.2	2.3	0.1	0	0.5	3.1	2.3	0	0	1	2.7
02-Feb-84	2.6	0.5	0	4.6	1.1	6.6	2.1	0	0	0.3	7.1	1.6	0	0	0.3
03-Feb-84	0	0	0	9	0	5.7	2.1	0	0.5	0.7	4.6	3.4	0	0	0.8
04-Feb-84															
05-Feb-84															
06-Feb-84	0	0	0	9	0	6.6	1.7	0	0	0.7	6.9	1.4	0	0	0.7
07-Feb-84	0	0	0	9	0	3.3	2.4	0	0	3.3	6.5	1.9	0	0	0.6
08-Feb-84	0.7	1.9	0	3.3	0.1	2.1	0.2	0.2	0.5	3	2.3	0.2	0	0.5	3
09-Feb-84	4.9	3.4	0	0.3	0.4	3.6	0.7	0	0	4.7	1.7	0.6	0	0	6.7
10-Feb-84	5.5	2.9	0	0	0.6	5.5	1.8	0	0	1.7	5.3	1.2	0.8	0	1.7
11-Feb-84															
12-Feb-84															
13-Feb-84	5.8	3	0	0	0.2	5.8	2.5	0.3	0	0.4	6.7	1.9	0	0	0.4
14-Feb-84	5.6	2.8	0	0	0.6	6.5	1.8	0	0	0.7	6.4	1.7	0.2	0	0.7
15-Feb-84	1.4	3.5	0	0	1.1	2.5	0.4	0	0	3.1	3.4	0	0	0	2.6
16-Feb-84	5.9	3	0	0	0.1	4.5	2.3	0.4	1	0.8	4.6	2.6	0	1	0.8
17-Feb-84	5.2	3.1	0	0.3	0.4	4.8	3.3	0	0	0.9	4.8	3.1	0	0	1.1
18-Feb-84															
19-Feb-84															
20-Feb-84	5.9	2.8	0	0	0.3	5.4	3.2	0	0	0.4	4.2	4.4	0	0	0.4
21-Feb-84	5.8	2.3	0	0.5	0.4	6.3	1.1	0	0.5	1.1	6	1.5	0	0.5	1
22-Feb-84	2.3	2.6	0	0.3	0.8	0.9	0.3	0	0	4.8	1	0.2	0	0	4.8

DATE	************* MILL #1 *************					************* MILL #2 *************					************* MILL #3 *************				
	Running Time		-------Downtime -------			Running Time		-------Downtime -------			Running Time		-------Downtime -------		
	Process	Idle	Blockage	Repairs	No-Fault	Process	Idle	Blockage	Repairs	No-Fault	Process	Idle	Blockage	Repairs	No-Fault
23-Feb-84	5.5	2.9	0	0	0.6	3.9	1.5	0	0.8	2.8	4.7	0.7	0	0.8	2.8
24-Feb-84	5.5	3.1	0	0	0.4	3.7	3.2	0	0	2.1	3.4	3.5	0	0	2.1
25-Feb-84															
26-Feb-84															
27-Feb-84	5.8	2.9	0	0	0.3	6.7	0.7	0	0	1.6	5.9	1.8	0.6	0	0.7
28-Feb-84	5.5	2.8	0.6	0	0.1	5.7	1.9	0.9	0	0.5	5.2	3.2	0	0	0.6
29-Feb-84	3.5	2.2	0	0	0.3	1.8	0.4	0	0	3.8	1.6	0.6	0	0	3.8
01-Mar-84	5.7	3	0	0	0.3	5.1	2.4	0	0	1.5	4.8	2.7	0	0	1.5
02-Mar-84	6.5	1.9	0	0	0.6	7.2	0.8	0	0	1	7.2	0.7	0	0	1.1
03-Mar-84															
04-Mar-84															
05-Mar-84	6.1	2.5	0	0.3	0.1	5.5	1.9	0.8	0	0.8	5.5	2	0.6	0	0.9
06-Mar-84	5.8	3.1	0	0	0.1	5	2	0.2	0	1.8	5.5	2.3	0.9	0	0.3
07-Mar-84	3.2	2.3	0	0.3	0.2	1.4	0.8	0	0.5	3.3	1.4	0.1	0	0.5	4
08-Mar-84	5.2	3.5	0	0	0.3	2.6	0.2	0	0	6.2	6.1	1.8	0.3	0	0.8
09-Mar-84	5.6	2.8	0	0.3	0.3	6.4	1.5	0	0	1.1	6.1	1.6	0.1	0	1.2
10-Mar-84															
11-Mar-84															
12-Mar-84	2.7	1	0	0.3	5	5.9	0.9	0	0	2.2	6	0.1	0.7	0	2.2
13-Mar-84	5	2.5	0	0	1.5	5.3	2.6	0	0	1.1	4.7	2.4	0.5	0	1.4
14-Mar-84	2.2	3.1	0	0	0.7	0	0	0	0	6	0	0	0	0.5	5.5
15-Mar-84	4.9	3.5	0	0	0.6	5.1	1.9	0.1	0	1.9	4.4	2.6	0.1	0	1.9
16-Mar-84	5	3.7	0	0	0.3	7.1	1.5	0	0	0.4	6.2	1.8	0.4	0	0.6
17-Mar-84															
18-Mar-84															
19-Mar-84	4.3	2.9	0	0	1.8	7.1	1.5	0	0	0.4	6.8	1.8	0.1	0	0.3
20-Mar-84	4.5	4.1	0	0	0.4	6.8	1.8	0	0	0.4	6.6	1.3	0.2	0.5	0.4
21-Mar-84	2.6	3.1	0	0	0.3	4.4	0.4	0	1	0.2	4.3	0.5	0	0	1.2
22-Mar-84	5.2	2	0.8	0.3	0.7	6.2	1.9	0.2	0	0.7	6.9	0.6	0.7	0	0.6
23-Mar-84	5.1	3.3	0.3	0	0.3	6.4	2.2	0	0	0.4	6.2	2.2	0	0	0.6
24-Mar-84															
25-Mar-84															
26-Mar-84	4.8	3.9	0	0	0.3	5.8	3	0	0	0.2	5.9	1.3	1.6	0	0.2
27-Mar-84	5	3.7	0	0	0.3	7.3	0.3	0.5	0.5	0.4	6.1	1.4	0.6	0.5	2.4
28-Mar-84	1.8	3.8	0	0	2.4	4	0.1	0	0	1.9	2.7	0.6	0	0	2.7
29-Mar-84	4.1	4.1	0.3	0.3	0.2	6.2	1.1	0.7	0.5	0.5	5.1	3.4	0	0	0.5
30-Mar-84	4.8	4.3	0	0	0.4	5.6	1.8	0	0	2.1	5.3	1.7	0	0	2.5
31-Mar-84															
01-Apr-84															
02-Apr-84	3.5	4.6	0.7	0	0.2	6.8	1.4	0.2	0	0.6	7.7	0.7	0	0	0.6
03-Apr-84	4.5	4	0	0	0.5	5.9	1.8	0	0	1.3	5.8	1.8	0	0	1.4
04-Apr-84	2.8	2.8	0.3	0	0.1	3.1	1	0	0	1.9	2.9	0.2	0	1	1.9
05-Apr-84	4.7	3.8	0	0	0.5	3.9	1.6	0	0	3.5	3.5	2.1	0	0	3.4
06-Apr-84	4.8	3.5	0	0	0.7	5.5	1.6	0	0.5	1.4	4.1	1.1	0	0	3.8
07-Apr-84															
08-Apr-84															
09-Apr-84															
10-Apr-84															
11-Apr-84															
12-Apr-84															
13-Apr-84															
14-Apr-84															

DATE	************* MILL #1 *************					************* MILL #2 *************					************* MILL #3 *************				
	Running Time		--------Downtime --------			Running Time		--------Downtime --------			Running Time		--------Downtime --------		
	Process	Idle	Blockage	Repairs	No-Fault	Process	Idle	Blockage	Repairs	No-Fault	Process	Idle	Blockage	Repairs	No-Fault
15-Apr-84															
16-Apr-84	0.8	0.8	0	0	7.4	2.5	0	0	0	8.5	0.5	0	0	0	8.5
17-Apr-84	1.2	5.3	0	0	2.5	0	0	0	0	9	0	0.3	0	0	8.7
18-Apr-84	2.6	4.7	0	0	0.7	0	0	0	0	6	0	0	0	0	6
19-Apr-84	4.4	4.3	0	0	0.3	3.5	0.6	0	0	4.9	2.3	0.6	0	0	5.9
20-Apr-84															
21-Apr-84															
22-Apr-84															
23-Apr-84	4	4.5	0	0	0.5	4.6	2.9	0	0	1.5	3.6	3.7	0	0	1.7
24-Apr-84	6.4	1.8	0.2	0	0.6	5.4	1.3	0	0	2.3	5.2	1.3	0.2	0	2.3
25-Apr-84	2.6	3	0	0	0.4	3	0.3	0	0	2.7	2.8	0.5	0	0	2.7
26-Apr-84	4.5	3.7	0	0	0.9	4.4	0.7	0	0	3.9	3.8	1.4	0	0	3.8
27-Apr-84	4.3	4.7	0	0	0.5	4.6	2.4	1.3	0.3	0.9	4.4	4.2	0	0	0.9
28-Apr-84															
29-Apr-84															
30-Apr-84	4.4	4.1	0	0	0.5	5.9	2.5	0	0	0.6	4.5	3	0	0.5	1
01-May-84	4.7	3.4	0.5	0	0.4	7	1.7	0	0	0.3	5.4	2.8	0	0.5	0.3
02-May-84	2.6	2.8	0.3	0	0.3	3.5	0.4	0	0	2.1	3.5	0.4	0	0	2.1
03-May-84	4.3	4.1	0	0.3	0.3	3.2	0.5	0	0	5.3	2.4	1.3	0	0	5.3
04-May-84	5.9	1.7	0	0	0.4	6.8	1.6	0	0	0.6	4.5	3.9	0	0	0.5
05-May-84															
06-May-84															
07-May-84	6.9	1.7	0	0	0.4	5	0.6	0	0	3.4	5.1	0.4	0.1	0	3.4
08-May-84	3.5	5	0	0	0.5	6.5	1.8	0.1	0	0.6	5.7	2.5	0.1	0	0.7
09-May-84	4.2	1.1	0.3	0	0.4	2.9	1.3	0	1	0.8	4.3	0.6	0.7	0	0.4
10-May-84	6.7	1.4	0.6	0	0.3	6.2	0.8	0	0	2	6.1	0.9	0	1	1
11-May-84	7.6	1.1	0	0	0.3	6.8	1.7	0	0	0.5	6.7	1.6	0	0	0.7
12-May-84															
13-May-84															
14-May-84	6.4	2	0	0.3	0.3	6.4	0.7	0	0	1.9	5.7	1.4	0	0	1.9
15-May-84	5.2	3.2	0	0.3	0.3	5	1.5	0	0	2.5	5.9	1	1.3	0	0.6
16-May-84	2.4	3.2	0	0	0.4	3.3	0.6	0	0	2.1	3	1.1	0	0	1.9
17-May-84	3.2	5.5	0	0	0.3	5.2	3.2	0	0	0.6	4.6	3.7	0.1	0	0.6
18-May-84	4.1	4.9	0	0	0.2	5.8	2.4	0.5	0	0.5	4.9	2.4	0.7	0.7	0.5
19-May-84															
20-May-84															
21-May-84	3.7	4.9	0	0	0.4	4.2	3.8	0.5	0	0.5	5.4	3.1	0	0	0.5
22-May-84	4	4.3	0.4	0	0.3	5.4	2.9	0	0	0.7	6	2.2	0	0	0.8
23-May-84	4.5	0.8	0.4	0	0.3	3	0.1	0	0	2.9	1.4	1.7	0	0	2.9
24-May-84	3.7	4.6	0.4	0	0.3	5.5	3	0	0	0.5	3.6	4.6	0	0	0.6
25-May-84	3.9	3.6	0.2	0.2	1	6.4	1.6	0	0	1	5.8	2.2	0	0	1
26-May-84															
27-May-84															
28-May-84	4.6	3.6	0	0	0.8	4.3	2.8	0	0	1.9	3.1	3.8	0.2	0	1.9
29-May-84	4.3	4.1	0	0.3	0.3	4.2	2.1	0	0	2.7	4.1	2.2	0	0	2.7
30-May-84	2.2	3.4	0	0	0.4	3.3	1.4	0	0	1.3	2.6	2.1	0	0	1.3
31-May-84	4	4.6	0	0	0.4	4.5	1.9	0	0	2.6	3.8	1.4	1	0	2.8
01-Jun-84	4.6	4.6	0	0	0.3	7.7	1.2	0	0	0.6	7.7	1	0	0	0.8
02-Jun-84															
03-Jun-84															
04-Jun-84	3.5	5.2	0	0	0.3	5.7	2.6	0	0	0.7	5.9	2.4	0	0	0.7
05-Jun-84	3.4	5.3	0	0	0.3	5.9	2.2	0	0	0.9	5.1	2	0.9	0	1

DATE	************* MILL #1 *************					************* MILL #2 *************					************* MILL #3 *************				
	Running Time		-------Downtime -------			Running Time		-------Downtime -------			Running Time		-------Downtime -------		
	Process	Idle	Blockage	Repairs	No-Fault	Process	Idle	Blockage	Repairs	No-Fault	Process	Idle	Blockage	Repairs	No-Fault
06-Jun-84	2.6	3.1	0	0	0.3	4	0.1	0	0	1.9	2.1	0.4	0	0	3.5
07-Jun-84	4.4	4.1	0.3	0	0.2	3.8	1.9	0	0	3.3	3.5	2	0	0	3.5
08-Jun-84	6.3	2.6	0.1	0	0.5	7.2	1.9	0	0	0.4	5	3.5	0	0	0.6
09-Jun-84															
10-Jun-84															
11-Jun-84	5.4	3.1	0	0.3	0.2	4.7	1.4	0.3	0	2.6	4.7	1.8	0	0	2.5
12-Jun-84	5.6	3.3	0	0	0.1	6.5	1.8	0.1	0	0.6	4.4	2.8	0.2	0.9	0.7
13-Jun-84	2.2	3.2	0.3	0	0.3	2	0.4	0	0	3.6	1.5	0.9	0	0	3.6
14-Jun-84	5	3.6	0	0	0.4	3.6	3.9	0.2	0	1.3	2.4	4.5	1.5	0	0.2
15-Jun-84	0	0	0	9	0	3.4	1.6	0	0	4	1.5	2.9	0.5	0	4.1
16-Jun-84															
17-Jun-84															
18-Jun-84	0	0	0	9	0	5.9	2.9	0	0	0.2	5.6	3.2	0	0	0.2
19-Jun-84	0	0	0	9	0	4.3	4	0.4	0	0.3	4.6	4.1	0	0	0.3
20-Jun-84	0	0	0	6	0	2	1.3	0	0	2.7	2.4	0.2	0.6	0	2.8
21-Jun-84	0	0	0	9	0	4.1	2.6	0	0	2.3	4.4	2.2	0.2	0	2.2
22-Jun-84	0	0	0	9	0	4	4.4	0	0	0.6	5.5	2.9	0	0	0.6
23-Jun-84															
24-Jun-84															
25-Jun-84	3.5	2.4	0	0.3	2.8	4.1	2.8	0.2	0	1.9	4.8	1.8	0.5	0	1.9
26-Jun-84	4.6	4.3	0	0	0.1	4.2	2.1	0	0	2.7	3.8	1.4	1.1	0	2.7
27-Jun-84	2.7	2.9	0	0	0.4	1.6	0.7	0	0	3.7	2.2	0.2	0	0	3.6
28-Jun-84	3.6	4.4	0	0.5	0.5	4.4	3.5	0	0	1.1	4.1	3.6	0	0	1.3
29-Jun-84	3.7	4.8	0	0	0.5	4.9	3.5	0	0	0.6	5	3.3	0	0	0.7
30-Jun-84															
01-Jul-84															
02-Jul-84	4.4	4.3	0	0	0.3	4	1	0	0	4	3.7	1.3	0	0	4
03-Jul-84	6.6	2.5	0	0	0.9	7	2.2	0	0	0.8	5.5	2.5	1.2	0	0.8
04-Jul-84															
05-Jul-84	4.3	4.2	0	0	0.5	5.9	2	0	0	1.1	5.6	2.5	0	0	0.9
06-Jul-84	4.7	3.3	0.4	0.3	0.3	3.9	2	0	0	3.1	3.3	3.1	0	0	2.6
07-Jul-84															
08-Jul-84															
09-Jul-84	4.1	4.6	0	0	0.3	4.3	1.5	0.1	0	3.1	3.8	3.2	0	0	2
10-Jul-84	5.1	3.2	0.5	0	0.2	5.8	3	0	0	0.2	5.3	2.4	1	0	0.3
11-Jul-84	1.9	2.2	0.3	0	1.6	2.2	0.1	0	0	3.7	2.3	0.3	0	0	3.4
12-Jul-84	3.1	5.1	0	0	0.8	5.7	2.6	0	0	0.7	5.2	3.1	0	0	0.7
13-Jul-84	4.7	5.2	0	0	0.1	2	0.9	0	0	7.1	1.5	1.1	0.3	0	7.1
14-Jul-84															
15-Jul-84															
16-Jul-84	3.8	4.9	0	0	0.3	0	0	0	9	0	0	0	0	9	0
17-Jul-84	6	2.7	0	0	0.3	0	0.5	0	8.5	0	0.5	0	0	8.5	0
18-Jul-84	3.6	1.1	0.3	0.5	1	0	0.8	0	0	5.7	0.8	0	0	0	5.7
19-Jul-84	4.5	4.2	0	0	0.3	5.1	1.4	0.1	0	2.4	2.9	3	0	0	3.1
20-Jul-84	5.7	3.1	0	0	0.7	4.4	4.5	0	0	0.6	3.7	2.2	3.2	0	0.4
21-Jul-84															
22-Jul-84															
23-Jul-84	6.3	2.1	0	0	0.6	5.2	2	0	0	1.8	5.6	2.1	0	0	1.3
24-Jul-84	3.8	4.2	0	0	1	5.1	1.4	0	0	2.5	4.7	4	0	0	0.3
25-Jul-84	2.2	2.9	0	0	0.9	1.2	3.8	0	0	1	0.7	4.3	0	0	1
26-Jul-84	5.5	2.1	0	0	0.4	5.4	1.6	0	0	2	4.8	2	0	0	2.2
27-Jul-84	5.7	3.5	0	0	0.3	2.4	6.1	0	0	1	4.6	3.7	0	0	1.2

	************** MILL #1 **************					************** MILL #2 **************					************** MILL #3 **************				
DATE	Running Time		-------Downtime -------			Running Time		-------Downtime -------			Running Time		-------Downtime -------		
	Process	Idle	Blockage	Repairs	No-Fault	Process	Idle	Blockage	Repairs	No-Fault	Process	Idle	Blockage	Repairs	No-Fault
28-Jul-84															
29-Jul-84															
30-Jul-84	4.9	1.1	0	0	3	3.7	1.3	0	0	4	4	1.6	0	0	3.4
31-Jul-84	4.4	4.3	0	0	0.3	4.9	3.8	0	0	0.3	4.4	3.7	0.7	0	0.2
01-Aug-84	2.9	1	0	0	2.1	4.4	0.1	0	0	1.5	1.6	1.2	0	0	3.2
02-Aug-84	4.9	3.8	0	0	0.3	4.8	0.5	0	0	3.7	6.4	1.4	0	0	1.2
03-Aug-84	5.8	2.6	0	0.3	0.3	6.3	1.8	0	0	0.9	6.3	1.8	0	0	0.9
04-Aug-84															
05-Aug-84															
06-Aug-84	5.9	2.9	0	0	0.2	6.5	0.2	0	0	2.3	5.6	1.1	0	0	2.3
07-Aug-84	5.1	3.1	0	0	0.6	5.3	3.4	0	0	0.3	5.7	2.5	0	0	0.4
08-Aug-84	2.4	2.9	0.2	0.3	0.2	1.8	2.4	0	0	1.8	0.6	4.8	0	0	0.6
09-Aug-84	4	2.4	0	0	2.6	4.2	1.1	0	0	3.7	4.6	1.4	0	0	3
10-Aug-84	4.7	2.8	0.1	0	1.4	6.1	1.9	0	0	1	6	1.5	0.5	0	1
11-Aug-84															
12-Aug-84															
13-Aug-84	4.7	3.9	0	0	0.4	5.6	1.7	0.1	0	1.6	4.6	2.7	0.1	0	1.5
14-Aug-84	5.1	3.1	0.3	0	0.5	5.7	2.6	0.2	0	0.5	4.9	3.6	0.1	0	0.4
15-Aug-84	2.4	2.7	0	0.3	0.6	1.2	0.2	0	0	4.6	0	0	0	0	6
16-Aug-84	4.2	4.3	0	0	0.5	4.3	1.4	0	0	3.3	3.7	1.9	0	0	3.4
17-Aug-84	4.4	3.7	0	0	0.9	3.5	1.5	0	0	4	3	1.8	0	0	4.2
18-Aug-84															
19-Aug-84															
20-Aug-84	5.1	3.4	0	0.2	0.3	5.1	0.8	0	0	3.1	4.7	1	0.2	0	3.1
21-Aug-84	5.4	3.3	0	0	0.3	5.1	3.6	0	0	0.3	4.7	3.7	0.3	0	0.3
22-Aug-84	1.8	3.1	0	0.3	0.8	2.8	0.5	0	0	2.7	0.4	0	0	0	5.6
23-Aug-84	4	4.4	0	0.3	0.3	3.4	1.6	1	0	3	3.8	4.2	0	0	1
24-Aug-84	4.8	3.7	0	0	0.5	4.2	2	0	0	2.8	3.8	1.4	0.2	0	3.6
25-Aug-84															
26-Aug-84															
27-Aug-84	5.3	3.5	0	0	0.2	5.2	3.2	0	0	0.6	4.4	4	0	0	0.6
28-Aug-84	5.4	2.8	0.5	0	0.3	5.6	1.7	0	0	1.7	4.6	2.4	0	0.1	1.7
29-Aug-84	2.2	2	0	0	1.8	3.9	1	0	0	1.1	1.3	0.5	0	0	4.2
30-Aug-84	4.6	3.9	0	0	0.5	3.3	1.7	0	0	4	3.7	3.5	0	0	1.8
31-Aug-84	4.5	2.9	0.6	0.7	0.3	3.8	1	0	0	4.2	3.5	1	0	0	4.5
01-Sep-84															
02-Sep-84															
03-Sep-84															
04-Sep-84															
05-Sep-84															
06-Sep-84															
07-Sep-84															
08-Sep-84															
09-Sep-84															
10-Sep-84	1.1	1.7	0	0	5.2	4	3.1	0.2	0	1.7	4.7	3.3	0	0	1
11-Sep-84	1.1	0.5	0	0.5	6.9	2.3	1.6	0	0	5.1	2.7	3	0	0	3.3
12-Sep-84	1.3	4.3	0	0	2.4	2.8	0.1	0	0	5.1	0.2	0	0	0	5.8
13-Sep-84	4.3	4.4	0	0	0.3	3.3	0.9	0.2	0	4.6	2.6	1.9	0	0	4.5
14-Sep-84	4.6	4.3	0	0	0.1	3.5	1.9	0	0	3.6	2.8	2.5	0	0	3.7
15-Sep-84															
16-Sep-84															
17-Sep-84	4.5	3.9	0	0	0.5	3.8	0.7	0	0	4.5	2.9	1.4	0	0	4.7

DATE	************* MILL #1 *************					************* MILL #2 *************					************* MILL #3 *************				
	Running Time		-------Downtime -------			Running Time		-------Downtime -------			Running Time		-------Downtime -------		
	Process	Idle	Blockage	Repairs	No-Fault	Process	Idle	Blockage	Repairs	No-Fault	Process	Idle	Blockage	Repairs	No-Fault
18-Sep-84	3.4	3.8	0.3	1.1	0.4	5.2	0.8	0	0	3	5	0.9	0	0	3.1
19-Sep-84	2.3	1.9	0	0	1.8	2.1	1.4	0	0	2.5	1.5	0.5	0	0	4
20-Sep-84	3.8	4.8	0	0	0.4	3.3	1.7	0	0	4	2.9	2	0	0	4.1
DAYS	175.00	175.00	175.00	175.00	175.00	175.00	175.00	175.00	175.00	175.00	175.00	175.00	175.00	175.00	175.00
WEEKS	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
AVERAGE	4.04	3.05	0.06	0.64	0.65	4.19	1.59	0.06	0.48	2.11	3.91	1.79	0.16	0.50	2.08
MAX VALUE	7.60	5.50	0.80	9.00	7.40	7.70	6.10	1.30	9.00	9.00	7.70	4.90	3.20	9.00	8.70
VARIANCE	3.02397	1.67905	0.02356	4.412445	1.03204	3.792987	1.21563	0.03806	3.504757	3.06632	3.809058	1.57198	0.14684	3.466895	3.38159
STD.DEV.	1.74	1.30	0.15	2.10	1.02	1.95	1.10	0.20	1.87	1.75	1.95	1.25	0.38	1.86	1.82
DEV/AVG	0.431	0.425	2.558	3.273	1.572	0.465	0.695	3.048	3.891	0.829	0.500	0.699	2.456	3.732	0.874
SUM	706.6	533.2	10.5	112.3	113.1	732.7	277.7	11.2	84.2	369.9	683.6	313.8	27.3	87.3	363.7

Appendix G

DATA SHEETS:
CALCULATED POWER CONSUMPTION AND
THROUGHPUT RATES

DATE	MILL #1 Power (kwh/ton)	MILL #3 Power (kwh/ton)	MILL #1 Rate (ton/hr) w/o idle	MILL #1 Rate (ton/hr) w/ idle	MILL #2 Rate (ton/hr) w/o idle	MILL #2 Rate (ton/hr) w/ idle	MILL #3 Rate (ton/hr) w/o idle	MILL #3 Rate (ton/hr) w/ idle	MILL #1 SHIFT (hrs)	MILL #2 SHIFT (hrs)	MILL #3 SHIFT (hrs)	MILL #2 & #3 Avg Rate w/o idle	MILL #2 & #3 Avg Rate w/ idle
	-----	-----											
02-Jan-84													
03-Jan-84					21.9	[illegible]	21.8	18.9	9	9	9	21.5	20.0
04-Jan-84					14.6	10.5	14.3	12.0	6	6	6	14.4	11.4
05-Jan-84			62.7	35.1					9	9	9		
06-Jan-84			56.1	32.1					9	9	9		
07-Jan-84													
08-Jan-84													
09-Jan-84			61.5	38.9					9	9	9		
10-Jan-84			75.7	38.7					9	9	9		
11-Jan-84			50.0	14.7					6	6	6		
12-Jan-84			55.8	34.9					9	9	9		
13-Jan-84			53.6	33.5					9	9	9		
14-Jan-84													
15-Jan-84													
16-Jan-84													
17-Jan-84			76.3	51.4	23.0	13.8	23.2	14.4	9	9	9	23.1	14.1
18-Jan-84			45.5	26.6					6	6	6		
19-Jan-84			69.9	44.1	21.6	13.6	21.3	14.2	9	9	9	21.4	14.0
20-Jan-84			41.5	26.8	15.1	12.6	15.3	13.0	9	9	9	15.2	12.8
21-Jan-84													
22-Jan-84													
23-Jan-84			58.8	43.5	22.8	16.9	22.8	17.5	9	9	9	22.8	17.2
24-Jan-84			62.4	42.3	23.8	12.7	23.6	10.9	9	9	9	23.7	11.7
25-Jan-84			50.8	36.7	14.6	9.0	14.7	6.4	6	6	6	14.6	7.7
26-Jan-84			69.6	45.9	22.7	13.4	22.4	14.1	9	9	9	22.5	13.8
27-Jan-84			73.9	38.2	17.1	12.1	17.2	14.4	9	9	9	17.1	13.2
28-Jan-84													
29-Jan-84													
30-Jan-84			70.2	47.0	24.3	18.9	24.1	17.1	9	9	9	24.2	18.0
31-Jan-84			71.9	43.8	24.0	16.6	24.0	18.3	9	9	9	24.0	18.5
01-Feb-84			42.1	16.7	7.0	6.7	7.0	7.0	6	6	6	7.0	6.8
02-Feb-84			27.7	23.2	16.1	12.2	16.1	13.1	9	9	9	16.1	12.6
03-Feb-84					13.5	9.9	13.5	7.9	9	9	9	13.5	8.9
04-Feb-84													
05-Feb-84													
06-Feb-84					11.7	9.3	11.6	9.6	9	9	9	11.6	9.5
07-Feb-84					15.5	8.9	15.4	11.9	9	9	9	15.4	10.7
08-Feb-84			26.6	7.7	4.8	4.3	5.2	4.8	6	6	6	5.0	4.6
09-Feb-84			55.3	32.7	16.4	13.7	16.5	12.2	9	9	9	16.4	13.2
10-Feb-84			47.1	30.8	14.4	10.8	14.5	11.8	9	9	9	14.4	11.3
11-Feb-84													
12-Feb-84													
13-Feb-84			65.2	43.2	21.0	14.7	21.2	16.5	9	9	9	21.1	15.6
14-Feb-84			70.5	47.0	22.9	18.0	22.8	18.0	9	9	9	22.9	18.0
15-Feb-84			57.9	16.5					6	6	6	0.0	0.0
16-Feb-84			47.3	31.3	16.7	11.0	16.5	10.6	9	9	9	16.6	10.8
17-Feb-84			49.6	31.1	18.3	10.9	18.5	11.3	9	9	9	18.4	11.1
18-Feb-84													
19-Feb-84													
20-Feb-84			38.1	25.9	16.3	10.2	16.2	7.9	9	9	9	16.3	9.1
21-Feb-84			70.5	50.5	15.6	13.2	15.5	12.4	9	9	9	15.5	12.8
22-Feb-84			57.8	27.1	8.9	6.7	8.0	5.7	6	6	6	8.4	6.7

DATE	MILL #1 Power (kwh/ton)	MILL #3 Power (kwh/ton)	MILL #1 Rate (ton/hr) w/o idle	MILL #1 Rate (ton/hr) w/ idle	MILL #2 Rate (ton/hr) w/o idle	MILL #2 Rate (ton/hr) w/ idle	MILL #3 Rate (ton/hr) w/o idle	MILL #3 Rate (ton/hr) w/ idle	MILL #1 SHIFT (hrs)	MILL #2 SHIFT (hrs)	MILL #3 SHIFT (hrs)	MILL #2 & #3 AVG RATE w/o idle	MILL #2 & #3 AVG RATE w/ idle
	-----	-----											
23-Feb-84			75.5	49.4	24.5	17.8	24.5	21.3	9	9	9	24.5	19.5
24-Feb-84			61.5	39.3	15.9	8.6	15.9	7.8	9	9	9	15.9	8.2
25-Feb-84													
26-Feb-84													
27-Feb-84			79.7	53.1	19.9	15.0	19.8	15.2	9	9	9	19.8	15.6
28-Feb-84			66.7	45.5	24.7	18.6	24.8	15.4	9	9	9	24.8	16.9
29-Feb-84			38.6	24.9	5.7	5.5	6.3	4.5	6	6	6	6.5	5.0
01-Mar-84			46.1	30.2	14.1	9.6	14.0	8.9	9	9	9	14.0	9.3
02-Mar-84			42.2	32.6	13.8	12.4	13.8	12.5	9	9	9	13.8	12.5
03-Mar-84													
04-Mar-84													
05-Mar-84			58.7	48.7	19.5	14.6	19.5	14.3	9	9	9	19.5	14.4
06-Mar-84			70.0	45.6	21.4	15.3	21.5	15.1	9	9	9	21.4	15.2
07-Mar-84			57.5	33.5	20.7	13.2	20.7	19.3	6	6	5	20.7	15.7
08-Mar-84			54.2	38.4	15.8	14.6	15.7	12.2	9	9	9	15.7	12.8
09-Mar-84			56.3	37.5	15.6	12.7	15.7	12.5	9	9	9	15.7	12.6
10-Mar-84													
11-Mar-84													
12-Mar-84			54.8	42.0	15.8	14.6	15.8	15.6	9	9	9	16.8	15.5
13-Mar-84			76.2	53.8	18.5	12.4	18.5	12.3	9	9	9	18.5	12.3
14-Mar-84			34.1	14.2					6	6	6		
15-Mar-84			63.9	37.3	15.1	11.0	15.0	9.4	9	9	9	15.1	10.2
16-Mar-84			75.0	45.1	13.0	10.7	13.1	10.1	9	9	9	13.0	10.4
17-Mar-84													
18-Mar-84													
19-Mar-84			84.2	50.3	18.2	15.0	18.1	14.3	9	9	9	18.1	14.7
20-Mar-84			83.3	43.6	18.4	14.5	18.5	15.4	9	9	9	18.4	15.0
21-Mar-84			69.6	31.8	9.8	9.0	9.5	8.5	6	5	5	9.7	8.8
22-Mar-84			52.5	45.1	14.0	10.7	14.1	12.9	9	9	9	14.0	11.6
23-Mar-84	3.4	4.9	69.0	41.9	13.3	9.9	13.2	9.8	9	9	9	13.3	9.8
24-Mar-84													
25-Mar-84													
26-Mar-84	2.4	3.0	87.9	48.5	17.8	11.7	17.6	14.4	9	9	9	17.7	12.9
27-Mar-84	2.6	5.6	91.4	52.5	17.8	17.1	17.7	14.4	9	9	9	17.8	15.8
28-Mar-84	4.1	7.7	80.6	25.9	9.8	9.5	9.6	7.9	6	6	6	9.7	8.8
29-Mar-84	3.2	11.3	91.5	45.7	13.9	11.8	13.9	8.4	9	9	9	13.9	9.9
30-Mar-84	3.2	7.6	79.0	41.6	14.8	11.2	14.9	11.3	9.5	9.5	9.5	14.9	11.3
31-Mar-84													
01-Apr-84													
02-Apr-84	3.2	11.0	90.0	38.9	15.9	13.2	14.2	13.0	9	9	9	15.0	13.1
03-Apr-84	2.7	3.7	97.6	51.6	18.0	13.8	18.1	13.6	9	9	9	16.0	13.8
04-Apr-84	3.3	8.2	87.9	43.9	16.1	12.2	16.9	15.8	6	6	6	16.5	13.8
05-Apr-84	3.2	8.0	67.0	37.1	13.1	9.3	14.3	8.9	9	9	9	13.6	9.1
06-Apr-84	4.6	12.0	54.6	31.6	9.3	7.2	12.2	9.6	9	9	9	10.5	8.2
07-Apr-84													
08-Apr-84													
09-Apr-84													
10-Apr-84													
11-Apr-84													
12-Apr-84													
13-Apr-84													
14-Apr-84													

DATE	MILL #1 Power (kwh/ton)	MILL #3 Power (kwh/ton)	MILL #1 Rate (ton/hr) w/o idle	MILL #1 Rate (ton/hr) w/ idle	MILL #2 Rate (ton/hr) w/o idle	MILL #2 Rate (ton/hr) w/ idle	MILL #3 Rate (ton/hr) w/o idle	MILL #3 Rate (ton/hr) w/ idle	MILL #1 SHIFT (hrs)	MILL #2 SHIFT (hrs)	MILL #3 SHIFT (hrs)	MILL #2 & #3 AVG RAT w/o idle	MILL #2 & #3 AVG RAT w/ idle
15-Apr-84													
16-Apr-84			30.0	15.0					9	9	9		
17-Apr-84			25.8	4.8					9	9	9		
18-Apr-84			61.7	7.0					6	6	6		
19-Apr-84			75.7	38.3	14.9	12.7	22.6	16.8	9	9	9	17.9	14.4
20-Apr-84													
21-Apr-84													
22-Apr-84													
23-Apr-84	2.4	7.3	105.8	49.8	17.8	10.9	22.8	11.2	9	9	9	20.2	11.1
24-Apr-84	2.3	7.3	68.4	53.4	20.4	16.4	21.2	16.9	9	9	9	20.8	16.7
25-Apr-84	2.5	11.8	90.8	42.1	11.3	10.3	12.1	10.3	6	6	6	11.7	10.3
26-Apr-84	2.6	10.3	64.2	46.2	13.4	11.6	15.3	11.2	9	9	9	14.3	11.4
27-Apr-84	3.3	9.0	84.2	40.2	14.6	9.6	15.2	7.8	9.5	9.5	9.5	14.9	8.6
28-Apr-84													
29-Apr-84													
30-Apr-84	2.5	6.5	87.7	45.4	21.0	14.8	27.3	16.4	9	9	9	23.8	15.5
01-May-84	2.7	8.7	77.9	45.2	13.3	10.7	17.0	11.2	9	9	9	14.9	10.9
02-May-84	3.0	22.2	75.8	36.5	5.4	4.9	5.1	4.6	6	6	6	5.3	4.7
03-May-84	3.3	4.9	53.7	42.9	13.1	11.4	17.1	11.1	9	9	9	14.8	11.2
04-May-84	3.3	16.3	52.9	42.4	7.4	6.0	10.9	5.8	9	9	9	8.8	5.9
05-May-84													
06-May-84													
07-May-84	1.8	9.2	63.9	51.3	13.2	11.8	12.7	11.8	9	9	9	13.0	11.5
08-May-84	2.5	6.6	114.3	47.1	18.9	14.8	21.4	14.9	9	9	9	20.1	14.9
09-May-84	4.0	19.4	60.2	47.7	10.7	7.4	7.2	5.3	6	6	6	8.6	5.8
10-May-84	2.6	7.7	46.4	38.4	8.5	7.5	8.5	7.4	9	9	9	8.5	7.5
11-May-84	3.3	13.3	48.6	42.4	11.0	6.8	11.2	5.0	9	9	9	11.1	8.9
12-May-84													
13-May-84													
14-May-84	2.9	6.9	54.2	41.3	14.2	12.8	15.8	12.7	9	9	9	15.0	12.7
15-May-84	2.9	9.4	60.6	49.9	17.2	13.2	14.4	12.3	9	9	9	15.7	12.0
16-May-84	3.2	20.2	62.5	35.4	6.4	5.4	6.7	4.9	6	6	6	6.5	5.1
17-May-84	4.6	11.6	77.5	26.5	13.1	8.1	15.0	9.3	9	9	9	14.0	8.2
18-May-84	2.9	9.4	84.9	36.7	14.7	10.4	17.3	11.6	9.2	9.2	9.2	15.9	11.0
19-May-84													
20-May-84													
21-May-84	3.1	10.0	83.4	38.0	19.0	10.0	14.6	9.4	9	9	9	16.7	9.7
22-May-84	2.6	9.9	57.3	46.9	18.9	12.3	16.6	12.3	9	9	9	17.8	12.3
23-May-84	4.4	13.3	42.7	34.5	5.0	4.8	10.7	4.8	6	6	6	6.8	4.8
24-May-84	3.6	12.7	75.7	33.7	11.5	7.4	15.5	7.5	9	9	9	13.5	7.5
25-May-84	3.4	8.9	75.4	39.7	14.2	11.4	15.5	11.3	9	9	9	14.6	11.3
26-May-84													
27-May-84													
28-May-84	3.7	13.6	58.7	32.9	10.5	5.3	14.2	6.4	9	9	9	12.0	5.4
29-May-84	2.8	2.3	64.2	43.1	20.5	13.7	21.2	13.7	9	9	9	20.7	13.7
30-May-84	3.7	36.4	37.7	30.4	7.0	4.9	8.5	4.7	6	6	6	7.5	4.8
31-May-84	3.5	5.5	35.3	39.7	16.2	11.4	15.2	14.0	9	9	9	17.6	12.6
01-Jun-84	3.4	9.4	69.8	44.9	13.9	12.0	13.8	12.2	9.5	9.5	9.5	13.6	12.1
02-Jun-84													
03-Jun-84													
04-Jun-84	3.3	7.9	86.9	34.9	17.7	12.2	17.1	12.2	9	9	9	17.4	12.2
05-Jun-84	3.3	6.1	106.2	41.5	16.8	12.2	19.2	13.8	9	9	9	17.9	13.0

DATE	MILL #1 Power (kwh/ton)	MILL #3 Power (kwh/ton)	MILL #1 Rate (ton/hr) w/o idle	MILL #1 Rate (ton/hr) w/ idle	MILL #2 Rate (ton/hr) w/o idle	MILL #2 Rate (ton/hr) w/ idle	MILL #3 Rate (ton/hr) w/o idle	MILL #3 Rate (ton/hr) w/ idle	MILL #1 SHIFT (hrs)	MILL #2 SHIFT (hrs)	MILL #3 SHIFT (hrs)	MILL #2 & #3 AVG RATES w/o idle	MILL #2 & #3 AVG RATES w/ idle
	-----	-----											
06-Jun-84	3.6	14.3	65.0	29.6	7.3	7.1	13.3	11.2	6	6	6	9.3	8.6
07-Jun-84	3.4	10.0	66.4	34.4	16.1	10.7	17.1	10.9	9	9	9	16.6	10.8
08-Jun-84	3.1	10.7	62.2	44.0	10.4	8.2	15.0	8.4	9.5	9.5	9.5	12.3	8.3
09-Jun-84													
10-Jun-84													
11-Jun-84	2.8	9.0	66.7	42.4	19.1	14.8	18.9	13.7	9	9	9	19.0	14.2
12-Jun-84	3.0	6.1	70.5	44.4	15.2	11.9	22.3	13.6	9	9	9	18.1	12.7
13-Jun-84	5.3	20.0	68.2	27.8	10.0	8.3	13.3	8.3	6	6	6	11.4	8.3
14-Jun-84	3.5	5.1	57.0	33.1	11.1	5.3	16.3	5.3	9	9	9	13.2	5.3
15-Jun-84					6.8	4.6	14.7	5.0	9	9	9	9.2	4.8
16-Jun-84													
17-Jun-84													
18-Jun-84					14.4	9.7	15.0	9.5	9	9	9	14.7	9.6
19-Jun-84					19.3	10.0	17.8	9.4	9	9	9	18.5	9.7
20-Jun-84					9.5	5.8	7.5	6.9	6	6	6	8.4	6.3
21-Jun-84					14.9	9.1	13.9	9.2	9	9	9	14.4	9.2
22-Jun-84					20.5	9.8	14.9	9.8	9	9	9	17.3	9.8
23-Jun-84													
24-Jun-84													
25-Jun-84	2.5	6.7	46.3	27.5	22.0	13.0	18.8	13.6	9	9	9	22.2	13.3
26-Jun-84	2.5	9.1	87.8	45.4	21.2	14.1	23.2	16.9	9	9	9	22.1	15.4
27-Jun-84	5.9		37.8	18.2	0.0	0.0	0.0	0.0	6	6	6	0.0	0.0
28-Jun-84	3.2	9.5	86.1	38.8	14.5	8.1	15.4	8.2	9	9	9	14.9	8.1
29-Jun-84	2.5	11.5	84.9	36.9	18.0	10.5	17.4	10.5	9	9	9	17.7	10.5
30-Jun-84													
01-Jul-84													
02-Jul-84	2.4	8.7	93.9	47.5	17.5	14.0	18.6	13.8	9	9	9	18.1	13.9
03-Jul-84	2.5	5.6	73.9	53.6	15.6	11.6	19.6	13.5	10	10	10	17.4	12.6
04-Jul-84													
05-Jul-84	2.9	5.9	80.7	40.8	17.5	13.0	19.2	12.6	9	9	9	17.8	12.8
06-Jul-84	2.6	10.8	81.3	47.8	19.0	12.5	22.4	11.6	9	9	9	20.6	12.0
07-Jul-84													
08-Jul-84													
09-Jul-84	2.6	4.9	93.4	44.0	18.8	14.0	21.3	11.6	9	9	9	20.0	12.7
10-Jul-84	2.3	6.8	83.7	51.4	20.2	13.3	22.1	15.2	9	9	9	21.1	14.2
11-Jul-84	4.5	8.0	46.3	21.5	11.4	12.9	10.9	9.6	6	6	6	[illegible]	12.2
12-Jul-84	2.7	11.1	96.5	36.5	12.6	8.7	13.3	8.7	9	9	9	13.2	8.7
13-Jul-84	3.9	15.4	65.7	31.2	13.5	9.3	17.3	10.0	10	10	10	15.1	9.6
14-Jul-84													
15-Jul-84													
16-Jul-84	2.6		121.1	44.1					9	9	9		
17-Jul-84	2.1		60.3	55.4					9	9	9		
18-Jul-84	2.7		62.8	43.1	0.0	10.0	10.0	12.0	6.5	6.5	6.5	20.0	10.0
19-Jul-84	2.8	10.5	78.2	48.5	11.2	6.0	19.7	9.7	9	9	9	14.3	9.2
20-Jul-84	2.6	12.3	68.4	44.3	14.8	7.3	17.6	11.0	9.5	9.5	9.5	16.0	6.8
21-Jul-84													
22-Jul-84													
23-Jul-84	2.3	6.5	68.3	51.2	15.1	13.1	15.5	12.1	9	9	9	17.3	12.6
24-Jul-84	3.3	7.0	53.9	30.4	20.0	15.7	21.7	11.7	9	9	9	20.8	13.4
25-Jul-84	5.6	10.5	49.1	21.2	15.6	3.8	27.1	3.8	6	6	6	22.0	3.3
26-Jul-84	2.7		44.9	34.0	18.1	14.2	20.2	14.3	9	9	9	19.1	14.1
27-Jul-84	3.0	7.0	58.2	36.1	42.9	12.1	22.2	12.3	9.5	9.5	9.5	23.3	12.2

DATE	MILL #1 Power (kwh/ton)	MILL #3 Power (kwh/ton)	MILL #1 Rate (ton/hr) w/o idle	MILL #1 Rate (ton/hr) w/ idle	MILL #2 Rate (ton/hr) w/o idle	MILL #2 Rate (ton/hr) w/ idle	MILL #3 Rate (ton/hr) w/o idle	MILL #3 Rate (ton/hr) w/ idle	MILL #1 SHIFT (hrs)	MILL #2 SHIFT (hrs)	MILL #3 SHIFT (hrs)	MILL #2 & #3 AVG RA w/o idle	MILL #2 & #3 AVG RA w/ idle
28-Jul-84													
29-Jul-84													
30-Jul-84	3.2	6.5	75.9	62.0	24.9	18.4	23.2	16.4	9	9	9	23.9	17.4
31-Jul-84	2.2	6.6	82.7	41.8	24.9	14.2	27.5	14.9	9	9	9	26.1	14.5
01-Aug-84	3.2	7.1	63.8	47.4	5.6	6.4	17.5	10.0	6	6	6	9.5	7.8
02-Aug-84	3.2	10.3	63.3	35.6	16.3	14.7	12.2	12.0	9	9	9	13.9	11.9
03-Aug-84	3.4	9.9	51.4	35.5	16.0	12.5	15.0	12.5	9	9	9	15.2	12.5
04-Aug-84													
05-Aug-84													
06-Aug-84	2.9	7.0	59.2	39.5	17.8	17.3	20.5	17.2	9	9	9	19.1	17.2
07-Aug-84	2.3	6.7	83.5	52.0	22.5	13.7	22.9	13.8	9	9	9	21.6	13.6
08-Aug-84	5.6		45.0	20.4					6	6	6	2.0	0.0
09-Aug-84	3.3	7.4	76.0	47.5	19.3	15.3	17.6	13.5	9	9	9	18.4	14.3
10-Aug-84	2.6	8.7	54.9	40.7	15.2	11.6	15.3	12.3	9	9	9	15.3	11.9
11-Aug-84													
12-Aug-84													
13-Aug-84	2.5	7.3	67.2	36.7	19.6	15.1	23.9	15.1	9	9	9	21.6	15.1
14-Aug-84	3.2	7.4	72.5	45.1	19.1	13.1	22.0	12.7	9	9	9	20.5	12.9
15-Aug-84	6.3	8.7	40.0	18.8	19.2	16.4			6	6	5	38.3	32.9
16-Aug-84	3.9	8.5	72.9	36.0	16.7	12.6	19.2	12.7	9	9	9	17.9	12.7
17-Aug-84	3.0	5.9	74.8	40.6	19.7	13.8	22.7	14.2	9	9	9	21.1	14.0
18-Aug-84													
19-Aug-84													
20-Aug-84	3.1	5.7	75.7	45.4	20.6	17.8	22.3	18.4	9	9	9	21.4	18.1
21-Aug-84	3.7	5.4	60.0	37.2	29.0	17.0	31.3	17.5	9	9	9	30.1	17.3
22-Aug-84	3.9	10.5	56.7	20.8	6.8	5.8	47.5	47.5	6	6	6	11.9	10.3
23-Aug-84	4.0	9.7	75.0	36.1	18.5	12.6	16.3	7.8	9	9	9	17.4	9.6
24-Aug-84	2.4	9.6	68.3	38.6	20.0	13.5	21.8	16.0	9	9	9	20.9	14.6
25-Aug-84													
26-Aug-84													
27-Aug-84	3.0	8.6	75.6	46.1	18.1	11.2	21.1	11.1	9	9	9	19.5	11.1
28-Aug-84	2.6	6.1	71.9	47.3	17.7	13.6	20.4	13.6	9	9	9	18.9	13.6
29-Aug-84	6.9	6.5	52.7	27.6	15.9	12.7	47.7	34.4	6	6	6	23.8	18.5
30-Aug-84	3.5	8.3	62.8	34.0	22.1	14.6	19.5	10.0	9	9	9	20.7	11.9
31-Aug-84	3.5	4.4	62.9	38.2	23.9	19.0	25.7	20.0	9	9	9	24.8	19.5
01-Sep-84													
02-Sep-84													
03-Sep-84													
04-Sep-84													
05-Sep-84													
06-Sep-84													
07-Sep-84													
08-Sep-84													
09-Sep-84													
10-Sep-84			15.5	6.1	21.0	11.0	17.7	10.4	9	9	9	19.2	11.1
11-Sep-84			67.3	46.3	24.3	14.4	20.4	9.6	9	9	9	22.2	11.6
12-Sep-84			60.0	13.9					6	6	6	0.0	0.0
13-Sep-84	2.9	10.3	79.8	39.4	11.8	9.3	15.0	8.7	9	9	9	13.2	9.0
14-Sep-84	2.0	9.5	70.3	40.4	18.3	11.9	22.5	11.9	9	9	9	20.2	11.9
15-Sep-84													
16-Sep-84													
17-Sep-84	2.4	8.0	91.3	49.4	13.4	11.3	17.2	11.6	9	9	9	15.1	11.5

DATE	MILL #1 Power (kwh/ton)	MILL #3 Power (kwh/ton)	MILL #1 Rate (ton/hr) w/o idle	MILL #1 Rate (ton/hr) w/ idle	MILL #2 Rate (ton/hr) w/o idle	MILL #2 Rate (ton/hr) w/ idle	MILL #3 Rate (ton/hr) w/o idle	MILL #3 Rate (ton/hr) w/ idle	MILL #1 SHIFT (hrs)	MILL #2 SHIFT (hrs)	MILL #3 SHIFT (hrs)	MILL #2 & #3 AVG RATES w/o idle	MILL #2 & #3 AVG RATES w/ idle
18-Sep-84	2.8	7.8	105.3	49.7	19.8	17.2	20.6	17.5	9	9	9	20.2	17.3
19-Sep-84	0.0	0.2	36.1	19.8	7.6	4.6	10.7	8.0	6	6	6	5.9	5.8
20-Sep-84	0.0	0.0	78.4	34.7	15.2	10.0	17.2	10.2	9	9	9	16.1	10.1
DAYS	105.00	99.00	164.00	164.00	158.00	158.00	157.00	157.00	175.00	175.00	175.00	161.00	161.00
WEEKS	21	19.8	32.8	32.8	31.6	31.6	31.4	31.4	35	35	35	32.2	32.2
AVERAGE	3.14	9.14	68.16	37.95	16.02	11.61	17.41	12.01	8.43	8.43	8.43	16.33	11.52
MAX VALUE	5.90	36.36	114.29	62.00	42.92	21.51	47.69	47.50	10.00	10.00	10.00	33.33	32.86
VARIANCE	0.964457	21.05616	312.1453	112.7251	30.81409	13.19810	36.22176	24.84529	1.491059	1.491059	1.491059	31.38801	17.76331
STD.DEV.	0.98	4.59	17.67	10.62	5.55	3.63	6.02	4.98	1.22	1.22	1.22	5.65	4.21
DEV/AVG	0.313	0.503	0.259	0.280	0.347	0.313	0.346	0.415	0.145	0.145	2.145	0.346	0.366
SUM									1475.7	1475.7	1475.7		

Appendix H

SHEAR SHREDDER DISCHARGE MATERIAL SIZE DISTRIBUTION DATA

SAMPLE: S-1 4" SHEAR

SCREEN SIZE:

	305	203	152	102	51	25	12.7	6.4	3.2		
mm / inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.00	1.21	6.05	2.38	0.40	0.12	0.00	0.00	10.15
PLASTIC	0.00	1.19	0.25	3.36	1.70	0.94	0.60	0.13	0.00	0.00	8.17
CARDBOARD	0.00	0.00	1.14	2.05	3.04	1.32	0.46	0.08	0.00	0.00	8.10
TEXTILES	2.89	0.00	0.00	0.00	0.18	0.23	0.00	0.00	0.00	0.00	3.31
WOOD	0.00	0.00	0.00	0.00	0.23	0.64	0.21	0.12	0.00	0.00	1.21
OTHR ORG	0.00	0.00	0.00	0.00	0.00	0.66	0.98	1.07	1.17	5.41	9.29
TTL ORG	2.89	1.19	1.39	6.61	11.21	6.18	2.65	1.52	1.17	5.41	40.23
GLASS	0.00	0.00	0.00	13.00	7.74	7.04	9.49	7.01	0.00	0.00	44.28
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.88	0.20	0.33	3.11	1.67	6.18
TTL INERT	0.00	0.00	0.00	13.00	7.74	7.92	9.69	7.34	3.11	1.67	50.47
FERROUS	0.00	0.00	4.27	0.00	0.03	0.73	2.76	0.03	0.10	0.10	8.02
NONFERROUS	0.00	0.00	0.00	0.00	1.01	0.21	0.03	0.02	0.00	0.00	1.28
TTL METALS	0.00	0.00	4.27	0.00	1.04	0.94	2.79	0.06	0.10	0.10	9.30
TOTAL	2.89	1.19	5.66	19.61	19.9[illegible]	15.05	15.13	8.92	4.38	7.18	100.00

SAMPLE: S-1

SCREEN SIZE:

	305	203	152	102	51	25	12.7	6.4	3.2		
mm / inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.00	11.89	59.61	23.45	3.91	1.14	0.00	0.00	100.00
PLASTIC	0.00	14.57	3.04	41.09	20.85	11.54	7.29	1.62	0.00	0.00	100.00
CARDBOARD	0.00	0.00	14.08	25.31	37.55	16.33	5.71	1.02	0.00	0.00	100.00
TEXTILES	87.50	0.00	0.00	0.00	5.50	7.00	0.00	0.00	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	0.00	19.18	53.42	17.81	9.59	0.00	0.00	100.00
OTHR ORG	0.00	0.00	0.00	0.00	0.00	7.12	10.50	11.57	12.63	5[illegible]	100.00
TTL ORG	7.19	2.96	3.45	16.44	27.87	15.37	6.58	3.78	2.92	13.4[illegible]	100.00
GLASS	0.00	0.00	0.00	0.00	0.00	7.12	10.50	11.57	12.63	58.19	100.00
OTHR INERT	0.00	0.00	0.00	29.35	17.48	15.91	21.43	15.83	0.00	0.00	100.00
TTL INERT	0.00	0.00	0.00	25.75	15.33	15.69	19.20	14.55	6.16	3.31	100.00
FERROUS	0.00	0.00	53.20	0.00	0.41	9.07	34.43	0.41	1.24	1.24	100.00
NONFERROUS	0.00	0.00	0.00	0.00	78.71	16.77	2.58	1.94	0.00	0.00	100.00
TTL METALS	0.00	0.00	45.87	0.00	11.[illegible]0	10.13	30.04	0.62	1.07	1.07	100.00
TOTAL	2.89	1.19	5.66	19.61	19.99	15.05	15.13	8.92	4.38	7.18	100.00

SAMPLE: S-2 4" SHEAR

SCREEN SIZE:

	mm inches	305 12	203 8	152 6	102 4	51 2	25 1	12.7 1/2	6.4 1/4	3.2 1/8	PAN	TOTAL
COMPONENT:												
	PAPER	0.00	0.00	0.98	9.34	5.92	4.99	1.22	0.26	0.00	0.00	22.72
	PLASTIC	0.00	0.18	5.20	4.59	2.55	1.23	0.27	0.07	0.00	0.00	14.09
	CARDBOARD	0.00	0.00	0.00	6.83	4.73	2.54	0.75	0.18	0.00	0.00	15.04
	TEXTILES	0.00	0.00	0.67	0.00	0.31	0.14	0.00	0.00	0.00	0.00	1.13
	WOOD	0.00	0.00	0.00	0.94	0.38	0.39	0.16	0.09	0.00	0.00	1.96
	OTHR ORG	0.00	0.00	1.60	3.04	2.17	5.69	3.73	4.03	3.37	0.00	23.64
	TTL ORG	0.00	0.18	8.45	24.76	16.07	14.98	6.14	4.63	3.37	0.00	78.58
	GLASS	0.00	0.00	0.00	0.00	0.64	1.52	4.52	4.55	0.00	0.00	11.23
	OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.53	0.65	0.09	2.25	0.00	3.53
	TTL INERT	0.00	0.00	0.00	0.00	0.64	2.05	5.17	4.65	2.25	0.00	14.76
	FERROUS	0.00	0.00	0.00	0.94	2.65	1.05	0.10	0.35	0.02	0.00	5.10
	NONFERROUS	0.00	0.00	0.00	0.38	0.85	0.26	0.03	0.02	0.01	0.00	1.56
	TTL METALS	0.00	0.00	0.00	1.32	3.50	1.31	0.14	0.37	0.03	0.00	6.66
	TOTAL	0.00	0.18	8.45	26.07	20.21	18.34	11.45	9.64	5.65	0.00	100.00

SAMPLE: S-2

SCREEN SIZE:

	mm inches	305 12	203 8	152 6	102 4	51 2	25 1	12.7 1/2	6.4 1/4	3.2 1/8	PAN	TOTAL
COMPONENT:												
	PAPER	0.00	0.00	4.32	41.14	26.06	21.96	5.37	1.15	0.00	0.00	100.00
	PLASTIC	0.00	1.30	36.89	32.59	18.12	8.70	1.92	0.49	0.00	0.00	100.00
	CARDBOARD	0.00	0.00	0.00	45.[illegible]	31.46	16.91	5.00	1.18	0.00	0.00	100.00
	TEXTILES	0.00	0.00	59.49	0.00	27.54	12.57	0.40	0.00	0.00	0.00	100.00
	WOOD	0.00	0.00	0.00	[illegible]	19.40	19.86	8.27	4.53	0.00	0.00	100.00
	OTHR ORG	0.00	0.00	6.77	[illegible]	9.19	24.09	15.78	17.05	14.25	0.00	100.00
	TTL ORG	0.00	0.23	10.76	31.50	20.45	19.07	7.81	5.89	4.29	0.00	100.00
	GLASS	0.00	0.00	6.77	12.88	9.19	24.09	15.78	17.05	14.25	0.00	100.00
	OTHR INERT	0.00	0.00	0.00	0.00	5.68	13.50	40.26	40.56	0.00	0.00	100.00
	TTL INERT	0.00	0.00	0.00	0.00	4.32	13.87	35.06	31.49	15.26	0.00	100.00
	FERROUS	0.00	0.00	0.00	18.43	51.[illegible]	20.49	2.02	6.80	0.36	0.00	100.00
	NONFERROUS	0.00	0.00	0.00	24.04	54.47	16.84	2.15	1.57	0.93	0.00	100.00
	TTL METALS	0.00	0.00	0.00	19.74	52.51	19.63	2.05	5.57	0.49	0.00	100.00
	TOTAL	0.00	0.18	8.45	26.07	20.21	18.34	11.45	9.64	5.65	0.00	100.00

SAMPLE: S-3 4" SHEAR

SCREEN SIZE:

COMPONENT: mm / inches	305 / 12	203 / 8	152 / 6	102 / 4	51 / 2	25 / 1	12.7 / 1/2	6.4 / 1/4	3.2 / 1/8	PAN	TOTAL
PAPER	0.00	0.00	0.00	10.77	7.23	3.98	1.07	0.12	0.00	0.00	23.17
PLASTIC	0.00	0.52	0.94	3.72	4.18	0.84	0.22	0.12	0.00	0.00	10.55
CARDBOARD	0.00	0.00	4.41	5.25	5.17	1.34	0.30	0.04	0.00	0.00	16.51
TEXTILES	0.00	0.00	1.29	2.68	1.12	0.16	0.08	0.00	0.00	0.00	5.34
WOOD	0.00	0.00	0.00	0.00	0.52	0.14	0.10	0.05	0.00	0.00	0.81
OTHR ORG	0.00	0.00	0.00	0.00	0.00	1.44	1.58	2.53	1.81	5.31	12.68
TTL ORG	0.00	0.52	6.64	22.42	18.22	7.91	3.35	2.87	1.81	5.31	69.05
GLASS	0.00	0.00	0.00	0.00	3.63	3.00	4.12	2.67	0.00	0.00	13.42
OTHR INERT	0.00	0.00	0.00	0.00	1.69	2.72	1.38	0.42	1.19	1.42	8.82
TTL INERT	0.00	0.00	0.00	0.00	5.32	5.71	5.50	3.09	1.19	1.42	22.24
FERROUS	0.00	0.00	1.12	2.36	0.82	0.74	0.46	0.50	0.00	0.15	6.15
NONFERROUS	0.00	0.00	0.00	0.13	1.81	0.52	0.10	0.02	0.00	0.00	2.56
TTL METALS	0.00	0.00	1.12	2.49	2.63	1.26	0.55	0.51	0.00	0.15	8.71
TOTAL	0.00	0.52	7.76	24.91	26.17	14.88	9.41	6.48	3.00	6.89	100.00

SAMPLE: S-3

SCREEN SIZE:

COMPONENT: mm / inches	305 / 12	203 / 8	152 / 6	102 / 4	51 / 2	25 / 1	12.7 / 1/2	6.4 / 1/4	3.2 / 1/8	PAN	TOTAL
PAPER	0.00	0.00	0.00	46.47	31.20	17.17	4.62	0.53	0.00	0.00	100.00
PLASTIC	0.00	4.95	8.88	35.29	39.67	8.01	2.10	1.11	0.00	0.00	100.00
CARDBOARD	0.00	0.00	26.71	31.80	31.33	8.10	1.79	0.27	0.00	0.00	100.00
TEXTILES	0.00	0.00	24.17	50.29	21.03	3.03	1.48	0.00	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	0.00	65.31	17.34	12.77	6.59	0.00	0.00	100.00
OTHR ORG	0.00	0.00	0.00	0.00	0.00	11.37	12.50	19.98	14.24	41.91	100.00
TTL ORG	0.00	0.76	9.61	32.47	26.39	11.45	4.86	4.16	2.61	7.70	100.00
GLASS	0.00	0.00	0.00	0.00	0.00	11.37	12.50	19.98	14.24	41.91	100.00
OTHR INERT	0.00	0.00	0.00	0.00	27.03	22.33	30.71	19.93	0.00	0.00	100.00
TTL INERT	0.00	0.00	0.00	0.00	23.90	25.69	24.74	13.91	5.36	6.40	100.00
FERROUS	0.00	0.00	18.24	38.42	13.38	12.01	7.40	8.08	0.00	2.46	100.00
NONFERROUS	0.00	0.00	0.00	4.91	70.47	20.27	3.76	0.60	0.00	0.00	100.00
TTL METALS	0.00	0.00	12.87	28.56	30.18	14.44	6.33	5.68	0.00	1.73	100.00
TOTAL	0.00	0.52	7.76	24.91	26.17	14.88	9.41	6.48	3.00	6.89	100.00

SAMPLE: S-4 4" SHEAR

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.00	3.72	5.55	2.70	0.77	0.40	0.22	0.00	13.36
PLASTIC	0.00	0.00	3.80	3.54	5.07	2.52	0.44	0.33	0.51	0.00	16.20
CARDBOARD	0.00	0.00	0.00	5.11	8.18	3.98	1.13	0.07	0.07	0.00	18.54
TEXTILES	0.00	0.00	0.00	0.00	1.79	1.09	1.53	0.00	0.00	0.00	4.42
WOOD	0.00	0.00	0.00	0.00	0.00	2.81	2.23	0.73	0.40	0.00	6.17
OTHR ORG	0.00	0.00	0.00	0.00	1.39	1.46	3.61	3.07	1.57	7.01	18.10
TTL ORG	0.00	0.00	3.80	12.37	21.97	14.56	9.71	4.60	2.77	7.01	76.79
GLASS	0.00	0.00	0.00	0.00	2.77	4.82	1.86	0.95	0.00	1.75	12.15
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	1.31	1.68
TTL INERT	0.00	0.00	0.00	0.00	2.77	4.82	1.86	0.95	0.36	3.07	13.83
FERROUS	0.00	0.00	0.00	1.13	1.75	4.34	0.44	0.11	0.04	0.03	7.84
NONFERROUS	0.00	0.00	0.00	0.00	0.66	0.62	0.22	0.04	0.00	0.00	1.53
TTL METALS	0.00	0.00	0.00	1.13	2.41	4.96	0.66	0.15	0.04	0.03	9.38
TOTAL	0.00	0.00	3.80	13.50	27.15	24.34	12.23	5.69	3.16	10.11	100.00

SAMPLE: S-4

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.00	27.87	41.53	20.22	5.74	3.01	1.64	0.00	100.00
PLASTIC	0.00	0.00	23.42	21.85	31.31	15.54	2.70	2.03	3.15	0.00	100.00
CARDBOARD	0.00	0.00	0.00	27.56	44.09	21.46	6.10	0.39	0.39	0.00	100.00
TEXTILES	0.00	0.00	0.00	0.00	40.50	24.79	34.71	0.00	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	0.00	0.00	45.56	36.09	11.83	6.51	0.00	100.00
OTHR ORG	0.00	0.00	0.00	0.00	7.66	8.06	19.96	16.94	8.67	38.71	100.00
TTL ORG	0.00	0.00	4.94	16.11	28.61	18.96	12.64	5.99	3.61	9.13	100.00
GLASS	0.00	0.00	0.00	0.00	7.66	8.06	19.96	16.94	8.67	38.71	100.00
OTHR INERT	0.00	0.00	0.00	0.00	22.82	39.64	15.32	7.81	0.00	14.41	100.00
TTL INERT	0.00	0.00	0.00	0.00	20.05	34.83	13.46	6.86	2.64	22.16	100.00
FERROUS	0.00	0.00	0.00	14.43	22.34	55.37	5.58	1.40	0.47	0.42	100.00
NONFERROUS	0.00	0.00	0.00	0.00	42.86	40.48	14.29	2.38	0.00	0.00	100.00
TTL METALS	0.00	0.00	0.00	12.07	25.69	52.94	7.01	1.56	0.39	0.35	100.00
TOTAL	0.00	0.00	3.80	13.50	27.15	24.34	12.23	5.69	3.18	10.11	100.00

SAMPLE: S-5 4" SHEAR

SCREEN SIZE:

	305	203	152	102		25	12.7	6.4	3.2		
mm / inches	12	8	6	4		1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.00	3.49	3.53	1.67	0.33	0.25	0.17	0.00	9.43
PLASTIC	0.00	0.00	7.59	3.47	6.86	1.36	0.19	0.31	0.36	0.00	20.15
CARDBOARD	0.00	8.42	0.00	8.28	3.03	3.44	0.56	0.00	0.06	0.00	23.78
TEXTILES	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.56
WOOD	0.00	0.00	0.00	0.00	0.00	1.64	1.33	0.42	0.67	0.00	4.06
OTHR ORG	0.00	0.00	0.00	0.00	1.19	0.58	5.00	2.14	1.03	5.00	14.94
TTL ORG	0.00	8.42	7.59	15.24	15.17	8.69	7.42	3.11	2.28	5.00	72.92
GLASS	0.00	0.00	0.00	9.23	1.89	3.00	1.11	0.56	0.00	0.04	15.82
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.39	1.17	2.11
TTL INERT	0.00	0.00	0.00	9.23	1.89	3.00	1.67	0.56	0.39	1.20	17.93
FERROUS	0.00	0.00	0.00	1.81	1.50	3.75	0.17	0.17	0.00	0.01	7.40
NONFERROUS	0.00	0.00	0.00	0.00	1.56	0.08	0.00	0.11	0.00	0.00	1.75
TTL METALS	0.00	0.00	0.00	1.81	3.06	3.83	0.17	0.28	0.00	0.01	9.15
TOTAL	0.00	8.42	7.59	26.28	20.11	15.53	9.25	3.94	2.67	6.22	100.00

SAMPLE: S-5

SCREEN SIZE:

	305	203	152	102	51	25	12.7	6.4	3.2		
mm / inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.00	36.98	37.40	17.67	3.53	2.65	1.77	0.00	100.00
PLASTIC	0.00	0.00	37.68	17.24	34.05	6.75	0.96	1.52	1.79	0.00	100.00
CARDBOARD	0.00	35.40	0.00	34.81	12.73	14.49	2.34	0.00	0.23	0.00	100.00
TEXTILES	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	0.00	0.00	40.41	32.88	10.27	16.44	0.00	100.00
OTHR ORG	0.00	0.00	0.00	0.00	7.99	3.90	33.46	14.31	6.88	33.46	100.00
TTL ORG	0.00	11.54	10.41	20.90	20.80	11.92	10.17	4.27	3.12	6.86	100.00
GLASS	0.00	0.00	0.00	0.00	7.99	3.90	33.46	14.31	6.88	33.46	100.00
OTHR INERT	0.00	0.00	0.00	58.34	11.94	18.96	7.02	3.51	0.00	0.23	100.00
TTL INERT	0.00	0.00	0.00	51.47	10.53	16.73	9.29	3.10	2.17	6.71	100.00
FERROUS	0.00	0.00	0.00	24.39	20.26	50.66	2.25	2.25	0.00	0.19	100.00
NONFERROUS	0.00	0.00	0.00	0.00	88.89	4.76	0.00	6.35	0.00	0.00	100.00
TTL METALS	0.00	0.00	0.00	19.73	33.38	41.[illegible]3	1.32	3.03	0.00	0.15	100.00
TOTAL	0.00	8.42	7.59	26.28	20.11	15.53	9.25	3.94	2.67	6.22	100.00

SAMPLE: S-6 4" SHEAR

SCREEN SIZE: mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.00	14.49	4.64	1.81	2.13	0.49	0.00	0.00	23.55
PLASTIC	0.00	0.00	13.65	0.72	2.92	1.72	1.41	0.67	0.00	0.00	21.09
CARDBOARD	0.00	0.00	0.00	1.51	0.00	0.81	0.81	0.63	0.00	0.00	3.75
TEXTILES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.37
WOOD	0.00	0.00	0.00	0.00	0.30	0.46	0.35	1.39	0.93	0.00	3.43
OTHR ORG	0.00	0.00	0.00	0.00	0.00	0.53	2.67	3.38	2.78	13.72	23.08
TTL ORG	0.00	0.00	13.65	16.71	7.86	5.33	7.37	6.93	3.71	13.72	75.28
GLASS	0.00	0.00	0.00	0.00	0.00	3.22	4.61	2.50	1.11	0.00	11.45
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	1.76	6.84	9.11
TTL INERT	0.00	0.00	0.00	0.00	0.00	3.22	4.61	3.01	2.87	6.84	20.56
FERROUS	0.00	0.00	0.00	0.00	1.11	0.15	0.06	0.02	0.06	0.23	1.63
NONFERROUS	0.00	0.00	0.00	0.00	2.41	0.05	0.07	0.00	0.00	0.00	2.53
TTL METALS	0.00	0.00	0.00	0.00	3.52	0.19	0.13	0.02	0.06	0.23	4.16
TOTAL	0.00	0.00	13.65	16.71	11.38	8.75	12.11	9.97	6.64	20.79	100.00

SAMPLE: S-6

SCREEN SIZE: mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.00	61.52	19.69	7.68	9.06	2.07	0.00	0.00	100.00
PLASTIC	0.00	0.00	64.73	3.41	13.85	8.13	6.70	3.19	0.00	0.00	100.00
CARDBOARD	0.00	0.00	0.00	40.12	0.00	21.60	21.60	16.67	0.00	0.00	100.00
TEXTILES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	0.00	8.78	13.51	10.14	40.54	27.03	0.00	100.00
OTHR ORG	0.00	0.00	0.00	0.00	0.00	2.31	11.55	14.66	12.05	59.44	100.00
TTL ORG	0.00	0.00	18.13	22.20	10.44	7.08	9.79	9.21	4.93	18.23	100.00
GLASS	0.00	0.00	0.00	0.00	0.00	2.31	11.55	14.66	12.05	59.44	100.00
OTHR INERT	0.00	0.00	0.00	0.00	0.00	28.14	40.28	21.86	9.72	0.00	100.00
TTL INERT	0.00	0.00	0.00	0.00	0.00	15.67	22.44	14.66	13.98	33.26	100.00
FERROUS	0.00	0.00	0.00	0.00	68.09	8.94	3.83	1.42	3.55	14.18	100.00
NONFERROUS	0.00	0.00	0.00	0.00	95.33	1.92	2.75	0.00	0.00	0.00	100.00
TTL METALS	0.00	0.00	0.00	0.00	84.63	4.68	3.17	0.56	1.39	5.57	100.00
TOTAL	0.00	0.00	13.65	16.71	11.38	8.75	12.11	9.97	6.64	20.79	100.00

SAMPLE: S-7 4" SHEAR

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTA
COMPONENT:											
PAPER	0.00	0.70	5.50	11.44	16.66	4.55	0.76	0.15	0.00	0.00	39.7
PLASTIC	0.00	0.00	0.00	1.92	1.80	1.42	1.06	0.51	0.00	0.00	6.7
CARDBOARD	0.00	0.00	0.82	6.23	4.69	0.49	0.47	0.13	0.00	0.00	12.8
TEXTILES	0.00	0.00	0.00	1.40	1.18	0.19	0.02	0.04	0.00	0.00	2.8
WOOD	0.00	0.00	0.00	0.00	2.13	2.07	0.57	0.27	0.00	0.00	5.0
OTHR ORG	0.00	0.00	0.00	1.61	0.00	0.74	1.14	1.71	1.14	4.18	10.5
TTL ORG	0.00	0.70	6.32	22.60	26.46	9.47	4.02	2.81	1.14	4.18	77.7
GLASS	0.00	0.00	0.00	0.00	2.28	3.83	3.19	3.61	1.23	0.00	14.1
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.19	0.23	1.16	2.1
TTL INERT	0.00	0.00	0.00	0.00	2.28	4.40	3.19	3.80	1.46	1.16	16.2
FERROUS	0.00	0.00	0.00	1.56	0.76	0.82	0.04	0.03	0.23	0.00	3.4
NONFERROUS	0.00	0.00	0.00	0.00	0.47	2.07	0.04	0.01	0.00	0.00	2.5
TTL METALS	0.00	0.00	0.00	1.56	1.23	2.88	0.08	0.04	0.23	0.00	6.0
TOTAL	0.00	0.70	6.32	24.16	29.97	16.76	7.29	6.64	2.83	5.33	100.0

SAMPLE: S-7

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTA
COMPONENT:											
PAPER	0.00	1.77	13.84	28.77	41.89	11.45	1.91	0.38	0.00	0.00	100.0
PLASTIC	0.00	0.00	0.00	28.53	26.84	21.19	15.82	7.63	0.00	0.00	100.0
CARDBOARD	0.00	0.00	6.36	48.52	36.54	3.85	3.70	1.04	0.00	0.00	100.0
TEXTILES	0.00	0.00	0.00	49.66	41.61	6.71	0.67	1.34	0.00	0.00	100.0
WOOD	0.00	0.00	0.00	0.00	42.26	41.13	11.32	5.28	0.00	0.00	100.0
OTHR ORG	0.00	0.00	0.00	15.34	0.00	7.04	10.83	16.25	10.83	39.71	100.0
TTL ORG	0.00	0.90	8.13	29.09	34.05	12.19	5.18	3.62	1.47	5.37	100.0
GLASS	0.00	0.00	0.00	15.34	0.00	7.04	10.83	16.25	10.83	39.71	100.0
OTHR INERT	0.00	0.00	0.00	0.00	16.11	27.11	22.55	25.50	8.72	0.00	100.0
TTL INERT	0.00	0.00	0.00	0.00	13.99	27.04	19.58	23.31	8.97	7.11	100.0
FERROUS	0.00	0.00	0.00	45.43	22.16	23.82	1.11	0.83	6.65	0.00	100.0
NONFERROUS	0.00	0.00	0.00	0.00	18.32	79.85	1.47	0.37	0.00	0.00	100.0
TTL METALS	0.00	0.00	0.00	25.87	20.50	47.95	1.26	0.63	3.79	0.00	100.0
TOTAL	0.00	0.70	6.32	24.16	29.97	16.76	7.29	6.64	2.83	5.33	100.0

SAMPLE: S-8 4" SHEAR

SCREEN SIZE:

COMPONENT: mm / inches	305 / 12	203 / 8	152 / 6	102 / 4	51 / 2	25 / 1	12.7 / 1/2	6.4 / 1/4	3.2 / 1/8	PAN	TOTAL
PAPER	0.00	0.46	0.77	5.86	4.96	1.96	0.55	0.12	0.00	0.00	14.67
PLASTIC	0.00	1.44	0.47	2.10	2.02	0.47	0.37	0.02	0.00	0.00	6.88
CARDBOARD	0.00	4.11	4.59	4.16	2.41	1.17	0.18	0.00	0.00	0.00	16.64
TEXTILES	0.00	3.73	0.00	1.00	0.04	0.47	0.00	0.01	0.00	0.00	5.26
WOOD	0.00	0.00	3.65	3.59	6.33	2.87	1.32	0.65	0.00	0.00	18.41
OTHR ORG	0.00	0.00	0.00	0.22	1.81	2.31	1.25	0.47	0.44	1.46	7.97
TTL ORG	0.00	9.74	9.49	16.94	17.58	9.25	3.67	1.27	0.44	1.46	69.84
GLASS	0.00	0.00	0.00	0.00	0.44	1.79	2.51	0.44	0.08	0.00	5.26
OTHR INERT	0.00	0.00	0.00	0.00	2.22	1.55	1.08	0.38	0.10	1.33	6.67
TTL INERT	0.00	0.00	0.00	0.00	2.66	3.34	3.59	0.82	0.18	1.33	11.93
FERROUS	0.00	0.00	7.48	0.00	6.46	0.50	0.54	0.05	0.16	0.00	15.17
NONFERROUS	0.00	0.00	0.00	0.00	1.59	0.54	0.90	0.01	0.03	0.00	3.06
TTL METALS	0.00	0.00	7.48	0.00	8.05	1.03	1.44	0.05	0.18	0.00	18.23
TOTAL	0.00	9.74	16.97	16.94	28.29	13.62	8.69	2.15	0.81	2.79	100.00

SAMPLE: S-8

SCREEN SIZE:

COMPONENT: mm / inches	305 / 12	203 / 8	152 / 6	102 / 4	51 / 2	25 / 1	12.7 / 1/2	6.4 / 1/4	3.2 / 1/8	PAN	TOTAL
PAPER	0.00	3.11	5.25	39.95	33.81	13.35	3.74	0.80	0.00	0.00	100.00
PLASTIC	0.00	20.85	6.82	30.52	29.38	6.82	5.31	0.28	0.00	0.00	100.00
CARDBOARD	0.00	24.71	27.61	25.02	14.51	7.06	1.10	0.00	0.00	0.00	100.00
TEXTILES	0.00	70.95	0.00	19.10	0.77	8.93	0.00	0.25	0.00	0.00	100.00
WOOD	0.00	0.00	19.84	19.49	34.37	15.59	7.16	3.54	0.00	0.00	100.00
OTHR ORG	0.00	0.00	0.00	2.78	22.75	28.97	15.71	5.89	5.56	18.33	100.00
TTL ORG	0.00	13.94	13.58	24.25	25.17	13.25	5.25	1.82	0.64	2.09	100.00
GLASS	0.00	0.00	0.00	2.78	22.75	28.97	15.71	5.89	5.56	18.33	100.00
OTHR INERT	0.00	0.00	0.00	0.00	8.44	34.00	47.64	8.44	1.49	0.00	100.00
TTL INERT	0.00	0.00	0.00	0.00	22.32	28.01	30.09	6.89	1.53	11.16	100.00
FERROUS	0.00	0.00	49.29	0.00	42.58	3.27	3.53	0.30	1.03	0.00	100.00
NONFERROUS	0.00	0.00	0.00	0.00	52.03	17.48	29.42	0.21	0.85	0.00	100.00
TTL METALS	0.00	0.00	41.02	0.00	44.17	5.65	7.87	0.29	1.00	0.00	100.00
TOTAL	0.00	9.74	16.97	16.94	28.29	13.62	8.69	2.15	0.81	2.79	100.00

SAMPLE: S-9 4" SHEAR

SCREEN SIZE:

	mm / inches	305 / 12	203 / 8	152 / 6	102 / 4	51 / 2	25 / 1	12.7 / 1/2	6.4 / 1/4	3.2 / 1/8	PAN	TOTA
COMPONENT:												
	PAPER	0.00	0.00	0.44	5.63	5.43	2.17	0.90	0.07	0.00	0.00	14.6
	PLASTIC	0.00	0.00	1.00	3.03	2.76	1.85	0.75	0.26	0.00	0.00	9.6
	CARDBOARD	0.00	1.10	3.67	7.14	4.11	1.28	1.04	0.27	0.00	0.00	18.6
	TEXTILES	0.00	3.11	2.23	3.38	3.03	0.77	0.00	0.05	0.00	0.00	12.5
	WOOD	0.00	0.00	0.00	0.00	2.05	0.37	0.18	0.07	0.00	0.00	2.6
	OTHR ORG	0.00	0.00	0.00	0.68	0.27	1.92	1.81	1.28	1.88	7.14	14.9
	TTL ORG	0.00	4.20	7.35	19.86	17.65	8.35	4.68	2.01	1.88	7.14	73.1
	GLASS	0.00	0.00	0.00	0.00	1.48	1.41	3.11	1.85	0.37	0.00	8.2
	OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.16	1.68	1.99	1.04	3.69	8.5
	TTL INERT	0.00	0.00	0.00	0.00	1.48	1.57	4.79	3.84	1.41	3.69	16.7
	FERROUS	0.00	0.00	0.73	0.00	4.15	0.51	0.71	0.02	0.07	0.00	6.1
	NONFERROUS	0.00	0.00	0.00	0.62	2.92	0.18	0.13	0.00	0.05	0.00	3.9
	TTL METALS	0.00	0.00	0.73	0.62	7.07	0.69	0.84	0.02	0.13	0.00	10.1
	TOTAL	0.00	4.20	8.08	20.48	26.20	10.62	10.31	5.87	3.42	10.84	100.0

SAMPLE: S-9

SCREEN SIZE:

	mm / inches	305 / 12	203 / 8	152 / 6	102 / 4	51 / 2	25 / 1	12.7 / 1/2	6.4 / 1/4	3.2 / 1/8	PAN	TOTAL
COMPONENT:												
	PAPER	0.00	0.00	3.00	38.45	37.08	14.86	6.12	0.50	0.00	0.00	100.00
	PLASTIC	0.00	0.00	10.42	31.44	28.60	19.13	7.77	2.65	0.00	0.00	100.00
	CARDBOARD	0.00	5.89	19.73	38.37	22.08	6.87	5.59	1.47	0.00	0.00	100.00
	TEXTILES	0.00	24.71	17.73	26.89	24.13	6.10	0.00	0.44	0.00	0.00	100.00
	WOOD	0.00	0.00	0.00	0.00	76.71	13.70	6.85	2.74	0.00	0.00	100.00
	OTHR ORG	0.00	0.00	0.00	4.51	1.83	12.80	12.07	8.54	12.56	47.68	100.00
	TTL ORG	0.00	5.75	10.04	27.16	24.14	11.42	6.40	2.75	2.57	9.77	100.00
	GLASS	0.00	0.00	0.00	4.51	1.83	12.80	12.07	8.54	12.56	47.68	100.00
	OTHR INERT	0.00	0.00	0.00	0.00	18.04	17.15	37.86	22.49	4.45	0.00	100.00
	TTL INERT	0.00	0.00	0.00	0.00	8.82	9.37	28.54	22.88	8.39	22.00	100.00
	FERROUS	0.00	0.00	11.80	0.00	66.96	8.26	11.50	0.29	1.18	0.00	100.00
	NONFERROUS	0.00	0.00	0.00	15.89	74.77	4.67	3.27	0.00	1.40	0.00	100.00
	TTL METALS	0.00	0.00	7.23	6.15	69.98	6.87	8.32	0.18	1.27	0.00	100.00
	TOTAL	0.00	4.20	8.08	20.48	26.20	10.62	10.31	5.87	3.42	10.84	100.00

SAMPLE: S-10 4" SHEAR

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.31	5.73	6.46	1.65	1.23	0.19	0.00	0.00	15.57
PLASTIC	0.00	0.00	0.58	3.75	1.19	2.50	0.75	0.21	0.00	0.00	8.98
CARDBOARD	0.00	0.00	0.00	4.82	6.65	4.06	1.96	0.40	0.00	0.00	17.88
TEXTILES	0.00	0.63	0.00	1.35	3.69	1.27	0.44	0.15	0.00	0.00	7.52
WOOD	0.00	0.00	0.00	0.58	2.11	0.65	0.46	0.38	0.00	0.00	4.17
OTHR ORG	0.00	0.00	0.00	0.00	0.63	1.63	2.33	1.19	1.83	5.75	13.36
TTL ORG	0.00	0.63	0.90	16.24	20.72	11.76	7.17	2.50	1.83	5.75	67.49
GLASS	0.00	0.00	0.00	0.00	2.33	1.90	2.46	2.50	2.38	0.00	11.57
OTHR INERT	0.00	0.00	0.00	0.00	1.23	0.25	1.61	2.36	1.48	2.92	9.84
TTL INERT	0.00	0.00	0.00	0.00	3.56	2.15	4.06	4.86	3.86	2.92	21.41
FERROUS	0.00	0.00	0.00	1.46	3.84	0.40	0.90	0.04	0.06	0.00	6.69
NONFERROUS	0.00	0.00	0.00	0.96	2.77	0.23	0.40	0.01	0.04	0.00	4.41
TTL METALS	0.00	0.00	0.00	2.42	6.61	0.63	1.29	0.05	0.10	0.00	11.10
TOTAL	0.00	0.63	0.90	18.66	30.89	14.53	12.53	7.41	5.79	8.67	100.00

SAMPLE: S-10

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	2.01	36.81	41.50	10.58	7.90	1.20	0.00	0.00	100.00
PLASTIC	0.00	0.00	6.50	41.76	13.23	27.84	8.35	2.32	0.00	0.00	100.00
CARDBOARD	0.00	0.00	0.00	26.92	37.18	22.73	10.96	2.21	0.00	0.00	100.00
TEXTILES	0.00	8.31	0.00	18.01	49.03	16.90	5.82	1.94	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	14.00	50.50	15.50	11.00	9.00	0.00	0.00	100.00
OTHR ORG	0.00	0.00	0.00	0.00	4.68	12.17	17.47	8.89	13.73	43.06	100.00
TTL ORG	0.00	0.93	1.33	24.06	30.70	17.42	10.62	3.71	2.72	8.52	100.00
GLASS	0.00	0.00	0.00	0.00	4.68	12.17	17.47	8.89	13.73	43.06	100.00
OTHR INERT	0.00	0.00	0.00	0.00	20.18	16.40	21.26	21.62	20.54	0.00	100.00
TTL INERT	0.00	0.00	0.00	0.00	16.65	10.03	18.90	22.69	18.01	13.63	100.00
FERROUS	0.00	0.00	0.00	21.81	57.32	5.92	13.40	0.62	0.93	0.00	100.00
NONFERROUS	0.00	0.00	0.00	21.75	62.88	5.20	8.98	0.24	0.95	0.00	100.00
TTL METALS	0.00	0.00	0.00	21.78	59.53	5.63	11.64	0.47	0.94	0.00	100.00
TOTAL	0.00	0.63	0.90	18.66	30.89	14.53	12.53	7.41	5.79	8.67	100.00

Figure H-1

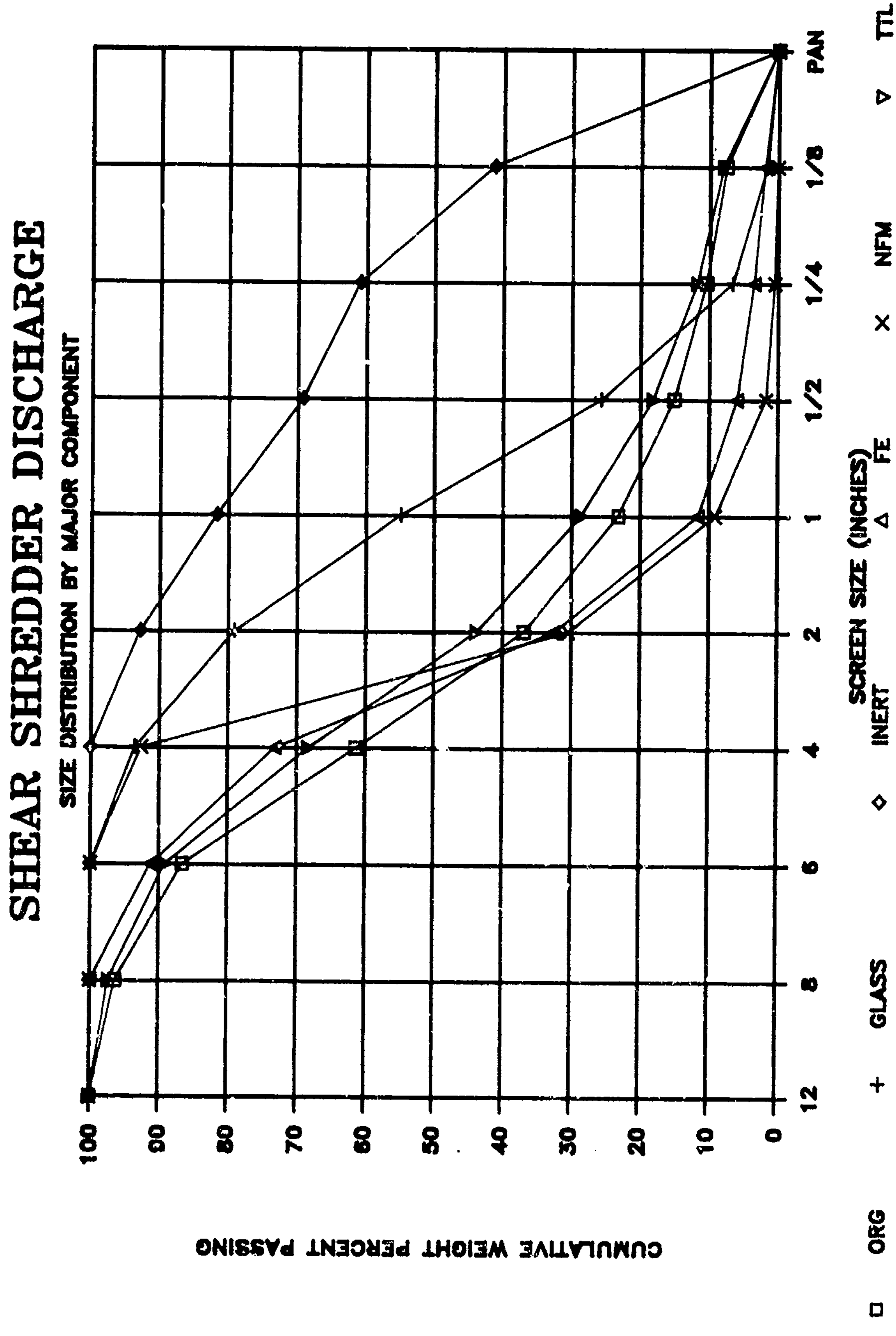
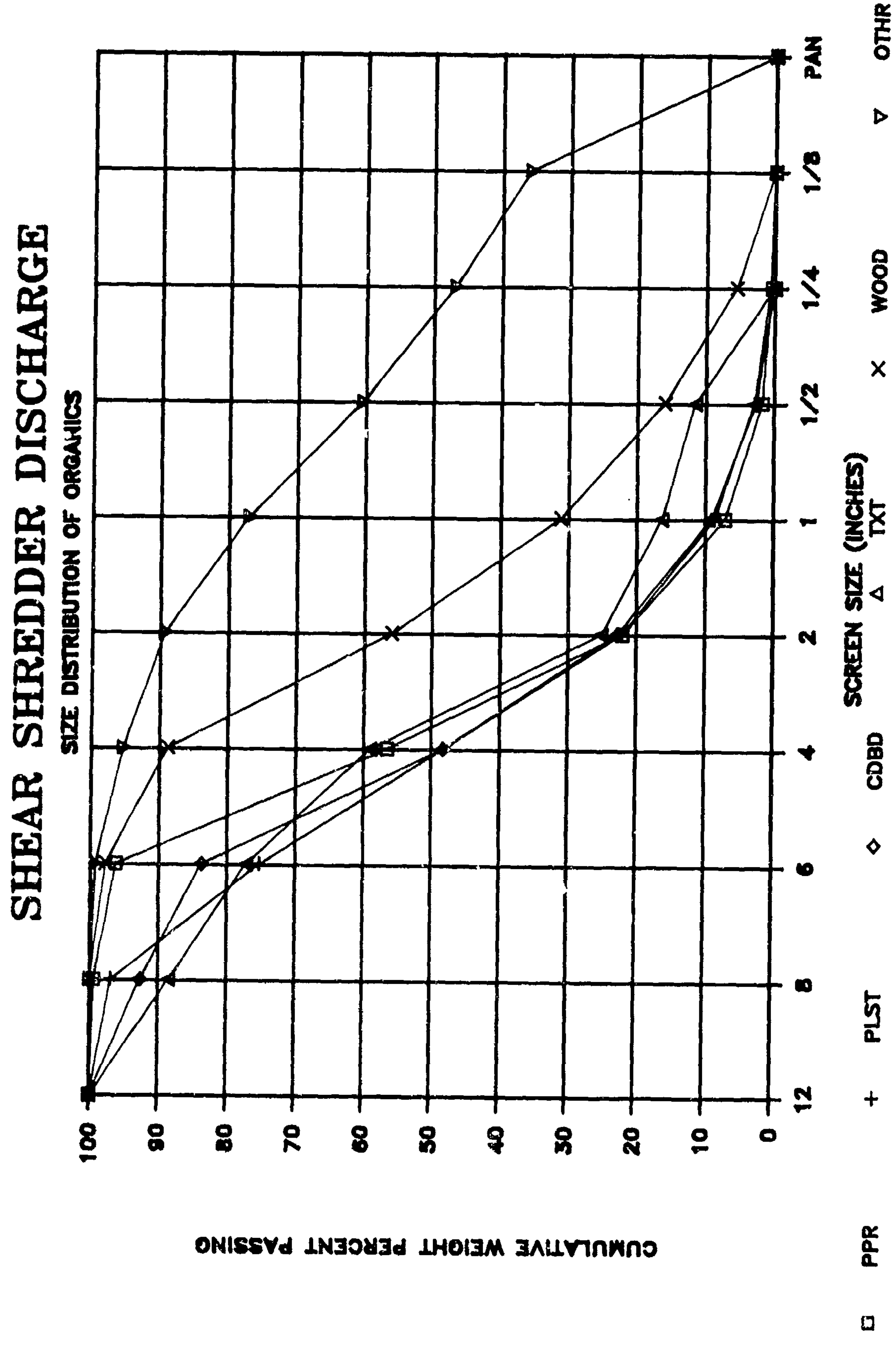

SHEAR SHREDDER DISCHARGE
SIZE DISTRIBUTION BY MAJOR COMPONENT
CUMULATIVE WEIGHT PERCENT PASSING
100
90
80
70
60
50
40
30
20
10
0
12
8
6
4
2
1
1/2
1/4
1/8
PAN
SCREEN SIZE (INCHES)
□ ORG
+ GLASS
◇ INERT
△ FE
× NFM
▽ TTL

Figure H-2


SHEAR SHREDDER DISCHARGE
SIZE DISTRIBUTION OF ORGANICS
CUMULATIVE WEIGHT PERCENT PASSING
100
90
80
70
60
50
40
30
20
10
0
12
8
6
4
2
1
1/2
1/4
1/8
PAN
SCREEN SIZE (INCHES)
□ PPR
+ PLST
◇ CDBD
Δ TXT
× WOOD
▽ OTHR

Appendix I

VERTICAL-SHAFT HAMMERMILL DISCHARGE MATERIAL SIZE DISTRIBUTION DATA

SAMPLE: H-1 HAMMERMILL

SCREEN SIZE:

COMPONENT:	305 mm / 12 inches	203 / 8	152 / 6	102 / 4	51 / 2	25 / 1	12.7 / 1/2	6.4 / 1/4	3.2 / 1/8	PAN	TOTAL
PAPER	0.00	0.00	0.00	3.22	6.57	9.00	6.82	1.05	0.00	0.00	26.66
PLASTIC	0.00	0.00	0.38	3.89	3.18	1.84	2.89	0.52	0.00	0.00	12.70
CARDBOARD	0.00	0.00	0.75	1.21	5.31	5.27	1.09	0.59	0.00	0.00	14.23
TEXTILES	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.38
WOOD	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.15	0.00	0.00	0.77
OTHR ORG	0.00	0.00	0.00	0.00	0.38	2.47	1.88	3.39	4.35	10.88	23.35
TTL ORG	0.00	0.00	1.13	8.33	15.44	18.96	13.31	5.69	4.35	10.88	78.08
GLASS	0.00	0.00	0.00	0.00	0.00	2.13	2.26	1.76	0.00	0.00	6.15
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.44	2.72	0.92	4.62
TTL INERT	0.00	0.00	0.00	0.00	0.00	2.13	2.80	2.20	2.72	0.92	10.78
FERROUS	0.00	0.00	0.00	0.00	6.11	2.55	0.25	0.88	0.02	0.04	9.85
NONFERROUS	0.00	0.00	0.00	0.00	0.75	0.29	0.17	0.06	0.01	0.00	1.29
TTL METALS	0.00	0.00	0.00	0.00	6.86	2.85	0.42	0.94	0.03	0.04	11.14
TOTAL	0.00	0.00	1.13	8.33	22.30	23.94	16.53	8.83	7.10	11.84	100.00

SAMPLE: H-1

SCREEN SIZE:

COMPONENT:	305 mm / 12 inches	203 / 8	152 / 6	102 / 4	51 / 2	25 / 1	12.7 / 1/2	6.4 / 1/4	3.2 / 1/8	PAN	TOTAL
PAPER	0.00	0.00	0.00	12.09	24.65	33.75	25.59	3.92	0.00	0.00	100.00
PLASTIC	0.00	0.00	2.97	30.64	25.04	14.50	22.73	4.12	0.00	0.00	100.00
CARDBOARD	0.00	0.00	5.29	8.53	37.35	37.06	7.65	4.12	0.00	0.00	100.00
TEXTILES	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	0.00	0.00	0.00	81.08	18.92	0.00	0.00	100.00
OTHR ORG	0.00	0.00	0.00	0.00	1.61	10.57	8.06	14.52	18.64	46.59	100.00
TTL ORG	0.00	0.00	1.45	10.66	19.77	24.28	17.04	7.29	5.57	13.93	100.00
GLASS	0.00	0.00	0.00	0.00	1.61	10.57	8.06	14.52	18.64	46.59	100.00
OTHR INERT	0.00	0.00	0.00	0.00	0.00	34.69	36.73	28.57	0.00	0.00	100.00
TTL INERT	0.00	0.00	0.00	0.00	0.00	19.81	26.02	20.39	25.24	8.54	100.00
FERROUS	0.00	0.00	0.00	0.00	62.00	25.90	2.55	8.92	0.21	0.42	100.00
NONFERROUS	0.00	0.00	0.00	0.00	58.54	22.76	13.01	4.88	0.81	0.00	100.00
TTL METALS	0.00	0.00	0.00	0.00	61.60	25.54	3.76	8.45	0.28	0.38	100.00
TOTAL	0.00	0.00	1.13	8.33	22.30	23.94	16.53	8.83	7.10	11.84	100.00

SAMPLE: H-2 HAMMERMILL

SCREEN SIZE:

	305	203	152	102	51	25	12.7	6.4	3.2		
mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.54	4.06	7.48	10.14	3.85	1.33	0.00	0.00	27.39
PLASTIC	0.00	0.59	1.34	4.21	2.44	2.28	1.45	0.32	0.00	0.00	12.63
CARDBOARD	0.00	0.00	0.00	4.41	5.54	6.58	3.28	0.99	0.00	0.00	20.80
TEXTILES	0.00	0.00	0.00	0.00	0.00	0.15	0.04	0.02	0.00	0.00	0.21
WOOD	0.00	0.00	0.00	0.00	0.00	0.51	0.44	0.30	0.00	0.00	1.25
OTHR ORG	0.00	0.00	0.00	0.00	0.00	3.95	3.59	6.00	5.88	0.00	19.42
TTL ORG	0.00	0.59	1.88	12.68	15.45	23.60	12.65	8.97	5.88	0.00	81.71
GLASS	0.00	0.00	0.00	0.00	0.00	0.29	2.10	5.11	0.00	0.00	7.50
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37	6.23	0.00	7.60
TTL INERT	0.00	0.00	0.00	0.00	0.00	0.29	2.10	6.48	6.23	0.00	15.10
FERROUS	0.00	0.00	0.00	0.46	0.61	0.85	0.28	0.00	0.00	0.00	2.20
NONFERROUS	0.00	0.00	0.00	0.00	0.20	0.35	0.18	0.16	0.10	0.00	0.99
TTL METALS	0.00	0.00	0.00	0.46	0.81	1.20	0.46	0.16	0.10	0.00	3.19
TOTAL	0.00	0.59	1.88	13.14	16.26	25.09	15.21	15.62	12.21	0.00	100.00

SAMPLE: H-2

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	1.97	14.81	27.30	37.00	14.06	4.85	0.00	0.00	100.00
PLASTIC	0.00	4.70	10.59	33.32	19.30	18.09	11.48	2.53	0.00	0.00	100.00
CARDBOARD	0.00	0.00	0.00	21.22	26.62	31.64	15.75	4.78	0.00	0.00	100.00
TEXTILES	0.00	0.00	0.00	0.00	0.00	69.57	19.13	11.30	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	0.00	0.00	40.65	35.05	24.30	0.00	0.00	100.00
OTHR ORG	0.00	0.00	0.00	0.00	0.00	20.32	18.51	30.90	30.27	0.00	100.00
TTL ORG	0.00	0.73	2.30	15.52	18.91	28.89	15.48	10.98	7.20	0.00	[illegible]
GLASS	0.00	0.00	0.00	0.00	0.00	20.32	18.51	30.90	30.27	[illegible]	[illegible]
OTHR INERT	0.00	0.00	0.00	0.00	0.00	3.80	28.01	68.19	0.00	[illegible]	[illegible]
TTL INERT	0.00	0.00	0.00	0.00	0.00	1.89	13.91	42.93	41.27	[illegible]	[illegible]
FERROUS	0.00	0.00	0.00	21.00	27.70	38.49	12.80	0.00	[illegible]	[illegible]	[illegible]
NONFERROUS	0.00	0.00	0.00	0.00	20.59	35.44	17.81	16.51	[illegible]	[illegible]	100.00
TTL METALS	0.00	0.00	0.00	14.48	25.49	37.54	14.36	[illegible]	[illegible]	[illegible]	100.00
TOTAL	0.00	0.59	1.88	13.14	16.26	25.09	15.21	15.62	[illegible]	[illegible]	100.00

SAMPLE: H-3 HAMMERMILL

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.00	2.90	6.37	16.01	5.85	4.61	0.00	0.00	35.7
PLASTIC	4.73	0.11	0.74	2.02	0.99	1.61	3.26	1.32	0.00	0.00	14.7
CARDBOARD	0.00	0.00	1.29	9.15	11.18	6.06	0.75	0.12	0.00	0.00	28.5
TEXTILES	0.00	0.00	0.00	0.00	1.84	0.21	0.00	0.01	0.00	0.00	2.0
WOOD	0.00	0.00	0.00	0.00	0.00	0.15	0.21	0.11	0.00	0.00	0.4
OTHR ORG	0.00	0.00	0.00	0.00	0.02	0.36	0.22	0.13	3.60	5.24	9.5
TTL ORG	4.73	0.11	2.03	14.07	20.40	24.40	10.29	6.29	3.60	5.24	91.1
GLASS	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.97	0.00	0.00	1.4
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.44	0.06	0.12	1.65	3.19	5.4
TTL INERT	0.00	0.00	0.00	0.00	0.00	0.44	0.54	1.09	1.65	3.19	6.9
FERROUS	0.00	0.00	0.00	0.86	0.50	0.00	0.05	0.00	0.00	0.08	1.4
NONFERROUS	0.00	0.00	0.00	0.00	0.00	0.18	0.14	0.11	0.00	0.00	0.4
TTL METALS	0.00	0.00	0.00	0.86	0.50	0.18	0.20	0.11	0.00	0.08	1.9
TOTAL	4.73	0.11	2.03	14.93	20.90	25.02	11.03	7.49	5.25	8.51	100.0

SAMPLE: H-3

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.00	8.12	17.83	44.78	16.38	12.89	0.00	0.00	100.00
PLASTIC	32.01	0.78	4.98	13.64	6.69	10.89	22.06	8.94	0.00	0.00	100.00
CARDBOARD	0.00	0.00	4.53	32.04	39.15	21.23	2.61	0.43	0.00	0.00	100.00
TEXTILES	0.00	0.00	0.00	0.00	89.41	10.01	0.21	0.36	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	0.00	0.00	32.50	44.06	23.44	0.00	0.00	100.00
OTHR ORG	0.00	0.00	0.00	0.00	0.23	3.77	2.28	1.31	37.62	54.79	100.00
TTL ORG	5.19	0.13	2.23	15.43	22.38	26.76	11.29	6.90	3.95	5.75	100.00
GLASS	0.00	0.00	0.00	0.00	0.23	3.77	2.28	1.31	37.62	54.79	100.00
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	33.13	66.87	0.00	0.00	100.00
TTL INERT	0.00	0.00	0.00	0.00	0.00	6.35	7.84	15.74	23.91	46.17	100.00
FERROUS	0.00	0.00	0.00	58.06	33.33	0.00	3.56	0.00	0.00	5.04	100.00
NONFERROUS	0.00	0.00	0.00	0.00	0.00	41.69	32.88	25.42	0.00	0.00	100.00
TTL METALS	0.00	0.00	0.00	44.95	25.80	9.42	10.18	5.74	0.00	3.91	100.00
TOTAL	4.73	0.11	2.03	14.93	20.90	25.02	11.03	7.49	5.25	8.51	100.00

SAMPLE: H-4 HAMMERMILL

SCREEN SIZE:

COMPONENT: mm / inches	305 / 12	203 / 8	152 / 6	102 / 4	51 / 2	25 / 1	12.7 / 1/2	6.4 / 1/4	3.2 / 1/8	PAN	TOTAL
PAPER	0.00	0.00	0.00	9.17	12.10	7.11	3.60	0.72	0.62	0.00	33.31
PLASTIC	0.00	0.00	8.39	0.57	0.62	1.85	0.46	0.10	0.72	0.00	12.72
CARDBOARD	0.00	0.00	0.00	9.89	3.86	1.65	1.44	0.41	0.93	0.00	18.18
TEXTILES	0.00	6.76	0.00	0.00	3.24	0.88	1.03	0.00	0.00	0.00	11.90
WOOD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHR ORG	0.00	0.00	0.00	0.00	0.36	0.62	5.20	2.32	1.54	6.80	16.84
TTL ORG	0.00	6.76	8.39	19.62	20.18	12.10	11.74	3.55	3.81	6.80	92.95
GLASS	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.21	0.57	0.21	1.96
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.62
TTL INERT	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.21	1.18	0.21	2.57
FERROUS	0.00	0.00	0.00	0.00	3.30	0.00	0.36	0.04	0.06	0.10	3.86
NONFERROUS	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.62
TTL METALS	0.00	0.00	0.00	0.00	3.91	0.00	0.36	0.04	0.06	0.10	4.47
TOTAL	0.00	6.76	8.39	19.62	24.10	12.10	13.08	3.79	5.06	7.11	100.00

SAMPLE: H-4

SCREEN SIZE:

COMPONENT: mm / inches	305 / 12	203 / 8	152 / 6	102 / 4	51 / 2	25 / 1	12.7 / 1/2	6.4 / 1/4	3.2 / 1/8	PAN	TOTAL
PAPER	0.00	0.00	0.00	27.51	36.32	21.33	10.82	2.16	1.85	0.00	100.00
PLASTIC	0.00	0.00	65.99	4.45	4.86	14.57	3.64	0.81	5.67	0.00	100.00
CARDBOARD	0.00	0.00	0.00	54.39	21.25	9.07	7.93	2.27	5.10	0.00	100.00
TEXTILES	0.00	56.75	0.00	0.00	27.25	7.35	8.65	0.00	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHR ORG	0.00	0.00	0.00	0.00	2.14	3.67	30.89	13.76	9.17	40.37	100.00
TTL ORG	0.00	7.27	9.03	21.11	21.72	13.02	12.63	3.82	4.10	7.31	100.00
GLASS	0.00	0.00	0.00	0.00	2.14	3.67	30.89	13.76	9.17	40.37	100.00
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	50.00	10.53	28.95	10.53	100.00
TTL INERT	0.00	0.00	0.00	0.00	0.00	0.00	38.00	8.00	46.00	8.00	100.00
FERROUS	0.00	0.00	0.00	0.00	85.45	0.00	9.35	0.93	1.60	2.67	100.00
NONFERROUS	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	100.00
TTL METALS	0.00	0.00	0.00	0.00	87.46	0.00	8.06	0.81	1.38	2.35	100.00
TOTAL	0.00	6.76	8.39	19.62	24.10	12.10	13.08	3.79	5.06	7.11	100.00

SAMPLE: H-5 HAMMERMILL

SCREEN SIZE: mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.00	7.18	5.75	5.93	2.76	0.76	0.89	0.00	23.27
PLASTIC	0.00	8.78	0.00	6.33	2.67	2.27	0.71	0.13	0.98	0.00	21.89
CARDBOARD	0.00	0.00	3.48	9.54	3.21	1.78	1.52	0.27	1.07	0.00	20.86
TEXTILES	0.00	0.00	0.00	1.38	3.61	0.98	0.49	0.45	0.00	0.00	6.91
WOOD	0.00	0.00	0.00	0.00	0.00	0.00	2.10	1.07	0.00	0.00	3.16
OTHR ORG	0.00	0.00	0.00	0.00	0.94	1.52	0.00	1.07	1.25	8.78	13.55
TTL ORG	0.00	8.78	3.48	24.43	16.18	12.48	7.58	3.74	4.19	8.78	89.64
GLASS	0.00	0.00	0.00	0.00	0.00	0.00	1.47	1.69	1.43	0.71	5.30
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.40
TTL INERT	0.00	0.00	0.00	0.00	0.00	0.00	1.47	1.69	1.83	0.71	5.71
FERROUS	0.00	0.00	0.00	0.98	1.29	0.40	0.71	0.04	0.04	0.06	3.54
NONFERROUS	0.00	0.00	0.00	0.00	0.94	0.00	0.18	0.00	0.00	0.00	1.11
TTL METALS	0.00	0.00	0.00	0.98	2.23	0.40	0.89	0.04	0.04	0.06	4.65
TOTAL	0.00	8.78	3.48	25.41	18.41	12.88	9.94	5.48	6.06	9.56	100.00

SAMPLE: H-5

SCREEN SIZE: mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.00	30.84	24.71	25.48	11.88	3.26	3.83	0.00	100.00
PLASTIC	0.00	40.12	0.00	28.92	12.22	10.39	3.26	0.61	4.48	0.00	100.00
CARDBOARD	0.00	0.00	16.67	45.73	15.38	8.55	7.26	1.28	5.13	0.00	100.00
TEXTILES	0.00	0.00	0.00	20.00	52.26	14.19	7.10	6.45	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	0.00	0.00	0.00	66.20	33.80	0.00	0.00	100.00
OTHR ORG	0.00	0.00	0.00	0.00	6.91	11.18	0.00	7.89	9.21	64.80	100.00
TTL ORG	0.00	9.80	3.88	27.25	18.05	13.92	8.45	4.18	4.67	9.80	100.00
GLASS	0.00	0.00	0.00	0.00	6.91	11.18	0.00	7.89	9.21	64.80	100.00
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	27.73	31.93	26.89	13.45	100.00
TTL INERT	0.00	0.00	0.00	0.00	0.00	0.00	25.78	29.69	32.03	12.50	100.00
FERROUS	0.00	0.00	0.00	27.71	36.52	11.34	20.15	1.26	1.26	1.76	100.00
NONFERROUS	0.00	0.00	0.00	0.00	84.00	0.00	16.00	0.00	0.00	0.00	100.00
TTL METALS	0.00	0.00	0.00	21.07	47.89	8.62	19.16	0.96	0.96	1.34	100.00
TOTAL	0.00	8.78	3.48	25.41	18.41	12.88	9.94	5.48	6.06	9.56	100.00

SAMPLE: H-6 HAMMERMILL

SCREEN SIZE:	305	203	152	102	51	25	12.7	6.4	3.2		
mm / inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.00	3.67	3.12	5.68	7.00	1.80	0.00	0.00	21.28
PLASTIC	0.00	0.00	0.00	0.00	0.03	2.15	0.83	1.11	0.00	0.00	4.12
CARDBOARD	0.00	0.00	0.00	0.00	0.35	0.83	1.11	1.32	0.00	0.00	3.60
TEXTILES	0.00	0.00	0.00	0.00	0.00	0.49	0.14	0.14	0.00	0.00	0.76
WOOD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.94	0.00	0.00	1.94
OTHR ORG	0.00	0.00	0.00	0.00	1.18	0.00	0.35	2.15	0.00	21.77	25.44
TTL ORG	0.00	0.00	0.00	3.67	4.68	9.15	9.43	8.46	0.00	21.77	57.16
GLASS	0.00	0.00	0.00	0.00	0.00	0.00	0.76	4.44	6.79	0.00	11.99
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	7.00	19.06	27.31
TTL INERT	0.00	0.00	0.00	0.00	0.00	0.00	0.76	5.68	13.80	19.06	39.31
FERROUS	0.00	0.00	0.00	0.00	0.00	0.42	0.97	0.07	0.07	0.83	2.36
NONFERROUS	0.00	0.00	0.00	0.00	0.00	0.28	0.69	0.21	0.00	0.00	1.18
TTL METALS	0.00	0.00	0.00	0.00	0.00	0.69	1.66	0.28	0.07	0.83	3.54
TOTAL	0.00	0.00	0.00	3.67	4.68	9.84	11.85	14.42	13.86	41.66	100.00

SAMPLE: H-6

SCREEN SIZE:	305	203	152	102	51	25	12.7	6.4	3.2		
mm / inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.00	17.26	14.66	26.71	32.90	8.47	0.00	0.00	100.00
PLASTIC	0.00	0.00	0.00	0.00	0.84	52.10	20.17	26.89	0.00	0.00	100.00
CARDBOARD	0.00	0.00	0.00	0.00	9.62	23.08	30.77	36.54	0.00	0.00	100.00
TEXTILES	0.00	0.00	0.00	0.00	0.00	63.64	18.18	18.18	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	100.00
OTHR ORG	0.00	0.00	0.00	0.00	4.63	0.00	1.36	8.45	0.00	85.56	100.00
TTL ORG	0.00	0.00	0.00	6.43	8.19	16.01	16.49	14.80	0.00	38.08	100.00
GLASS	0.00	0.00	0.00	0.00	4.63	0.00	1.36	8.45	0.00	85.56	100.00
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	6.36	36.99	56.65	0.00	100.00
TTL INERT	0.00	0.00	0.00	0.00	0.00	0.00	1.94	14.46	35.10	48.50	100.00
FERROUS	0.00	0.00	0.00	0.00	0.00	17.65	41.18	2.94	2.94	35.29	100.00
NONFERROUS	0.00	0.00	0.00	0.00	0.00	23.53	58.82	17.65	0.00	0.00	100.00
TTL METALS	0.00	0.00	0.00	0.00	0.00	19.61	47.06	7.84	1.96	23.53	100.00
TOTAL	0.00	0.00	0.00	3.67	4.68	9.84	11.85	14.42	13.86	41.66	100.00

SAMPLE: H-7 HAMMERMILL

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	0.27	2.21	6.06	7.73	3.30	3.63	0.00	0.00	23.19
PLASTIC	0.00	0.00	0.00	1.89	2.86	1.79	3.04	1.51	0.00	0.00	11.08
CARDBOARD	0.00	0.00	1.51	8.98	4.93	1.28	3.99	0.71	0.00	0.00	21.40
TEXTILES	0.00	5.07	0.66	0.00	0.72	0.59	0.76	0.11	0.00	0.00	7.91
WOOD	0.00	0.00	0.00	2.29	2.72	0.00	1.19	0.00	0.00	0.00	6.20
OTHR ORG	0.00	0.00	0.00	0.00	0.00	0.84	1.28	0.19	5.67	2.85	10.83
TTL ORG	0.00	5.07	2.43	15.36	17.29	12.23	13.56	6.14	5.67	2.85	80.61
GLASS	0.00	0.00	0.00	0.00	0.18	1.02	2.29	2.54	0.00	0.00	6.03
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.24	0.34	0.00	3.50	3.97	8.05
TTL INERT	0.00	0.00	0.00	0.00	0.18	1.27	2.63	2.54	3.50	3.97	14.08
FERROUS	0.00	0.00	0.00	1.44	2.16	0.28	0.14	0.38	0.00	0.00	4.40
NONFERROUS	0.00	0.00	0.00	0.00	0.62	0.18	0.08	0.03	0.00	0.00	0.91
TTL METALS	0.00	0.00	0.00	1.44	2.79	0.46	0.21	0.41	0.00	0.00	5.31
TOTAL	0.00	5.07	2.43	16.80	20.25	13.95	16.41	9.09	9.17	6.82	100.00

SAMPLE: H-7

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	1.15	9.53	26.15	33.33	14.22	15.64	0.00	0.00	100.00
PLASTIC	0.00	0.00	0.00	17.03	25.77	16.15	27.47	13.59	0.00	0.00	100.00
CARDBOARD	0.00	0.00	7.05	41.97	23.03	5.99	18.67	3.31	0.00	0.00	100.00
TEXTILES	0.00	64.06	8.30	0.00	9.13	7.48	9.59	1.44	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	36.93	43.87	0.00	19.19	0.00	0.00	0.00	100.00
OTHR ORG	0.00	0.00	0.00	0.00	0.00	7.72	11.79	1.74	52.39	26.36	100.00
TTL ORG	0.00	6.29	3.02	19.06	21.44	15.17	16.82	7.62	7.04	3.54	100.00
GLASS	0.00	0.00	0.00	0.00	0.00	7.72	11.79	1.74	52.39	26.36	100.00
OTHR INERT	0.00	0.00	0.00	0.00	2.93	16.97	37.97	42.12	0.00	0.00	100.00
TTL INERT	0.00	0.00	0.00	0.00	1.26	8.99	18.68	18.03	24.87	28.18	100.00
FERROUS	0.00	0.00	0.00	32.70	49.11	6.34	3.16	8.69	0.00	0.00	100.00
NONFERROUS	0.00	0.00	0.00	0.00	68.80	20.06	8.36	2.79	0.00	0.00	100.00
TTL METALS	0.00	0.00	0.00	27.12	52.47	8.68	4.04	7.68	0.00	0.00	100.00
TOTAL	0.00	5.07	2.43	16.80	20.25	13.95	16.41	9.09	9.17	6.82	100.00

SAMPLE: H-8 HAMMERMILL

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	4.24	2.98	6.71	11.57	4.55	2.91	0.00	0.00	32.95
PLASTIC	0.00	0.00	0.00	3.17	4.34	2.95	3.70	1.69	0.00	0.00	15.85
CARDBOARD	0.00	0.00	3.81	4.46	4.19	4.68	1.40	0.44	0.00	0.00	18.98
TEXTILES	0.00	0.00	0.00	0.99	1.97	1.56	1.25	0.03	0.00	0.00	5.80
WOOD	0.00	0.00	0.00	1.27	0.94	0.24	0.13	0.05	0.00	0.00	2.64
OTHR ORG	0.00	0.00	0.00	0.16	1.72	0.00	0.83	0.00	4.28	4.95	11.94
TTL ORG	0.00	0.00	8.05	13.03	19.86	21.01	11.86	5.11	4.28	4.95	88.16
GLASS	0.00	0.00	0.00	0.00	0.00	0.58	0.35	1.61	0.00	0.00	2.54
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	2.54	3.05	5.96
TTL INERT	0.00	0.00	0.00	0.00	0.00	0.58	0.35	1.98	2.54	3.05	8.50
FERROUS	0.00	0.00	0.00	0.29	0.73	0.44	0.23	0.05	0.14	0.00	1.87
NONFERROUS	0.00	0.00	0.00	1.03	0.23	0.13	0.06	0.03	0.00	0.00	1.48
TTL METALS	0.00	0.00	0.00	1.32	0.95	0.57	0.29	0.08	0.14	0.00	3.34
TOTAL	0.00	0.00	8.05	14.35	20.81	22.15	12.50	7.17	6.97	8.00	100.00

SAMPLE: H-8

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	12.87	9.04	20.35	35.11	13.80	8.83	0.00	0.00	100.00
PLASTIC	0.00	0.00	0.00	19.99	27.38	18.64	23.33	10.66	0.00	0.00	100.00
CARDBOARD	0.00	0.00	20.08	23.50	22.06	24.67	7.38	2.31	0.00	0.00	100.00
TEXTILES	0.00	0.00	0.00	17.04	33.94	26.88	21.65	0.49	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	48.31	35.78	9.21	4.82	1.87	0.00	0.00	100.00
OTHR ORG	0.00	0.00	0.00	1.36	14.38	0.00	6.98	0.00	35.81	41.46	100.00
TTL ORG	0.00	0.00	9.14	14.78	22.53	23.83	13.45	5.80	4.85	5.62	100.00
GLASS	0.00	0.00	0.00	1.36	14.38	0.00	6.98	0.00	35.81	41.46	100.00
OTHR INERT	0.00	0.00	0.00	0.00	0.00	22.80	13.74	63.46	0.00	0.00	100.00
TTL INERT	0.00	0.00	0.00	0.00	0.00	6.81	4.10	23.31	29.94	35.84	100.00
FERROUS	0.00	0.00	0.00	15.26	38.82	23.49	12.08	2.64	7.70	0.00	100.00
NONFERROUS	0.00	0.00	0.00	69.98	15.30	8.60	4.21	1.91	0.00	0.00	100.00
TTL METALS	0.00	0.00	0.00	39.41	28.44	16.92	8.61	2.32	4.33	0.00	100.00
TOTAL	0.00	0.00	8.05	14.35	20.81	22.15	12.50	7.17	6.97	8.00	100.00

SAMPLE: H-9 HAMMERMILL

SCREEN SIZE: mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTA
COMPONENT:											
PAPER	0.00	0.00	0.76	2.82	4.68	11.59	3.84	2.32	0.00	0.00	26.0
PLASTIC	0.00	0.00	1.20	2.99	4.29	2.21	1.26	1.66	0.00	0.00	13.6
CARDBOARD	0.00	2.21	0.00	7.20	6.53	9.95	1.90	0.64	0.00	0.00	28.4
TEXTILES	0.00	0.00	0.00	1.71	3.72	1.88	0.17	0.11	0.00	0.00	7.5
WOOD	0.00	0.00	0.00	0.00	0.00	1.74	0.14	0.06	0.00	0.00	1.9
OTHR ORG	0.00	0.00	0.00	0.00	0.48	0.22	0.30	0.22	4.22	6.28	11.7
TTL ORG	0.00	2.21	1.96	14.71	19.71	27.59	7.61	5.01	4.22	6.28	89.3
GLASS	0.00	0.00	0.00	0.00	0.00	0.00	0.81	1.09	0.00	0.00	1.9
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.26	0.16	0.28	2.07	2.82	5.5
TTL INERT	0.00	0.00	0.00	0.00	0.00	0.26	0.96	1.37	2.07	2.82	7.4
FERROUS	0.00	0.00	0.00	0.76	1.10	0.51	0.19	0.02	0.01	0.00	2.5
NONFERROUS	0.00	0.00	0.00	0.33	0.00	0.16	0.14	0.01	0.00	0.00	0.6
TTL METALS	0.00	0.00	0.00	1.09	1.10	0.67	0.33	0.02	0.01	0.00	3.2
TOTAL	0.00	2.21	1.96	15.80	20.81	28.53	8.90	6.40	6.29	9.10	100.0

SAMPLE: H-9

SCREEN SIZE: mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	2.93	10.83	18.00	44.56	14.77	8.91	0.00	0.00	100.0
PLASTIC	0.00	0.00	8.80	21.94	31.54	16.23	9.26	12.23	0.00	0.00	100.0
CARDBOARD	0.00	7.77	0.00	25.33	22.98	35.01	6.67	2.24	0.00	0.00	100.0
TEXTILES	0.00	0.00	0.00	22.54	48.98	24.80	2.25	1.43	0.00	0.00	100.0
WOOD	0.00	0.00	0.00	0.00	0.00	89.60	7.20	3.20	0.00	0.00	100.0
OTHR ORG	0.00	0.00	0.00	0.00	4.12	1.86	2.52	1.86	35.99	53.65	100.0
TTL ORG	0.00	2.47	2.19	16.48	22.07	30.90	8.52	5.61	4.72	7.04	100.0
GLASS	0.00	0.00	0.00	0.00	4.12	1.86	2.52	1.86	35.99	53.65	100.0
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	42.62	57.38	0.00	0.00	100.0
TTL INERT	0.00	0.00	0.00	0.00	0.00	3.53	12.89	18.30	27.65	37.63	100.0
FERROUS	0.00	0.00	0.00	29.43	42.64	19.82	7.21	0.60	0.30	0.00	100.0
NONFERROUS	0.00	0.00	0.00	51.85	0.00	24.[illegible]9	22.22	1.23	0.00	0.00	100.0
TTL METALS	0.00	0.00	0.00	33.82	34.30	20.77	10.14	0.72	0.24	0.00	100.0
TOTAL	0.00	2.21	1.96	15.80	20.81	28.53	8.90	6.40	6.29	9.10	100.0

SAMPLE: H-10 HAMMERMILL

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	1.15	1.49	7.23	7.56	5.83	2.79	0.00	0.00	26.05
PLASTIC	0.00	0.00	0.00	5.34	2.00	1.67	0.88	0.70	0.00	0.00	10.59
CARDBOARD	0.00	0.00	0.00	4.24	7.58	6.22	3.21	0.54	0.00	0.00	21.80
TEXTILES	6.37	0.00	0.00	1.86	3.28	1.62	0.47	0.06	0.00	0.00	13.65
WOOD	0.00	0.00	0.00	0.00	1.91	1.06	0.26	0.09	0.00	0.00	3.32
OTHR ORG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03	4.24	5.87	11.13
TTL ORG	6.37	0.00	1.15	12.93	22.00	18.13	10.66	5.20	4.24	5.87	86.54
GLASS	0.00	0.00	0.00	0.00	0.00	0.25	0.60	1.29	0.00	0.00	2.14
OTHR INERT	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.31	2.95	2.90	6.59
TTL INERT	0.00	0.00	0.00	0.00	0.00	0.25	1.03	1.60	2.95	2.90	8.73
FERROUS	0.00	0.00	0.00	0.00	1.63	0.67	0.88	0.23	0.06	0.09	3.56
NONFERROUS	0.00	0.00	0.00	0.00	0.71	0.34	0.10	0.01	0.00	0.00	1.16
TTL METALS	0.00	0.00	0.00	0.00	2.34	1.01	0.99	0.25	0.06	0.09	4.73
TOTAL	6.37	0.00	1.15	12.93	24.33	19.38	12.67	7.05	7.25	8.86	100.00

SAMPLE: H-10

SCREEN SIZE:

mm	305	203	152	102	51	25	12.7	6.4	3.2		
inches	12	8	6	4	2	1	1/2	1/4	1/8	PAN	TOTAL
COMPONENT:											
PAPER	0.00	0.00	4.43	5.72	27.75	29.00	22.39	10.72	0.00	0.00	100.00
PLASTIC	0.00	0.00	0.00	50.45	18.86	15.77	8.34	6.58	0.00	0.00	100.00
CARDBOARD	0.00	0.00	0.00	19.47	34.79	28.52	14.73	2.49	0.00	0.00	100.00
TEXTILES	46.66	0.00	0.00	13.60	23.99	11.87	3.46	0.41	0.00	0.00	100.00
WOOD	0.00	0.00	0.00	0.00	57.61	32.01	7.74	2.64	0.00	0.00	100.00
OTHR ORG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.22	38.07	52.71	100.00
TTL ORG	7.36	0.00	1.33	14.94	25.42	20.94	12.31	6.01	4.90	6.78	100.00
GLASS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.22	38.07	52.71	100.00
OTHR INERT	0.00	0.00	0.00	0.00	0.00	11.75	28.01	60.25	0.00	0.00	100.00
TTL INERT	0.00	0.00	0.00	0.00	0.00	2.88	11.79	18.34	33.81	33.19	100.00
FERROUS	0.00	0.00	0.00	0.00	45.62	18.84	24.82	6.55	1.64	2.54	100.00
NONFERROUS	0.00	0.00	0.00	0.00	61.06	28.89	8.79	1.26	0.00	0.00	100.00
TTL METALS	0.00	0.00	0.00	0.00	49.41	21.31	20.88	5.25	1.24	1.91	100.00
TOTAL	6.37	0.00	1.15	12.93	24.33	19.38	12.67	7.05	7.25	8.86	100.00

Figure I-1

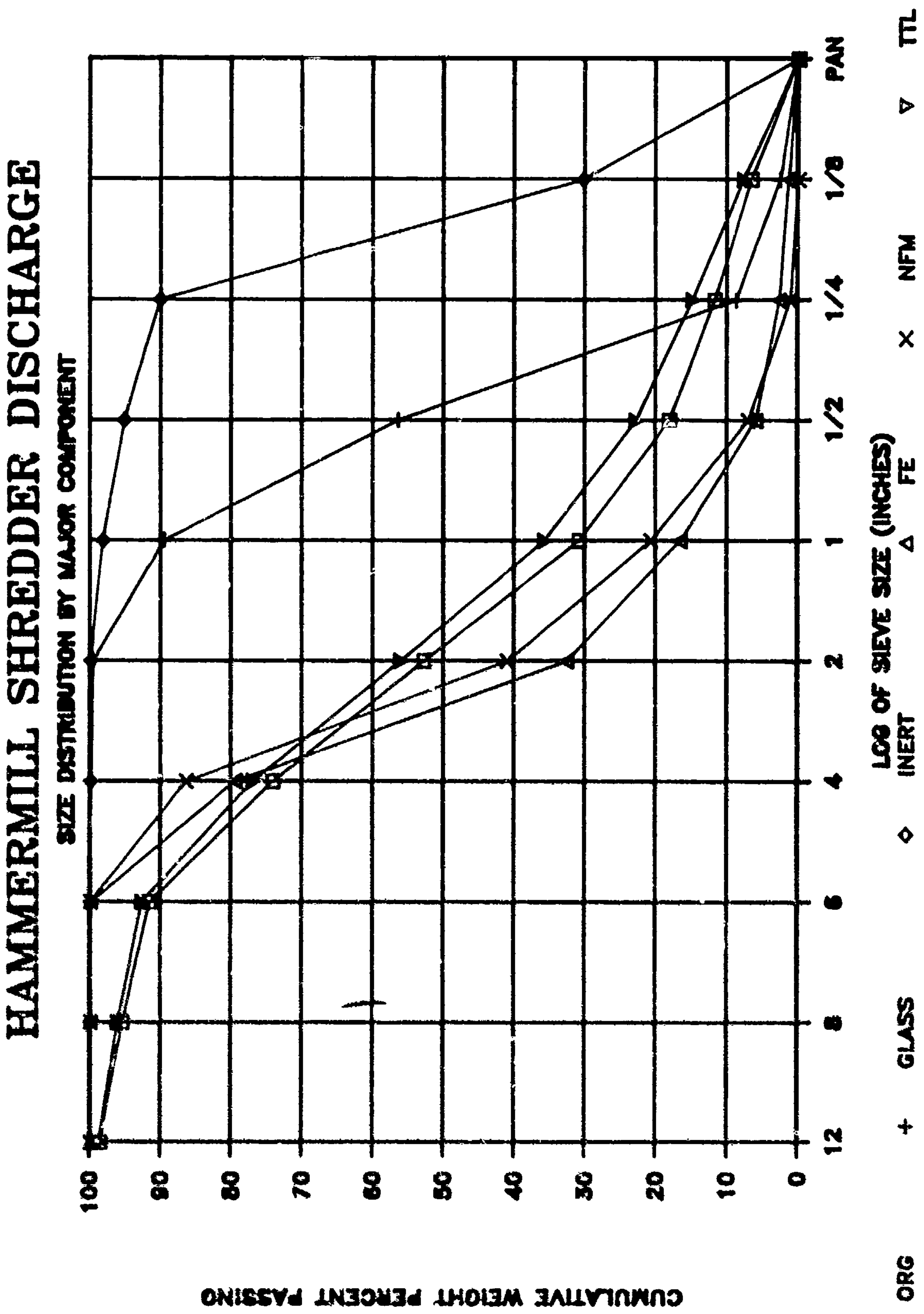
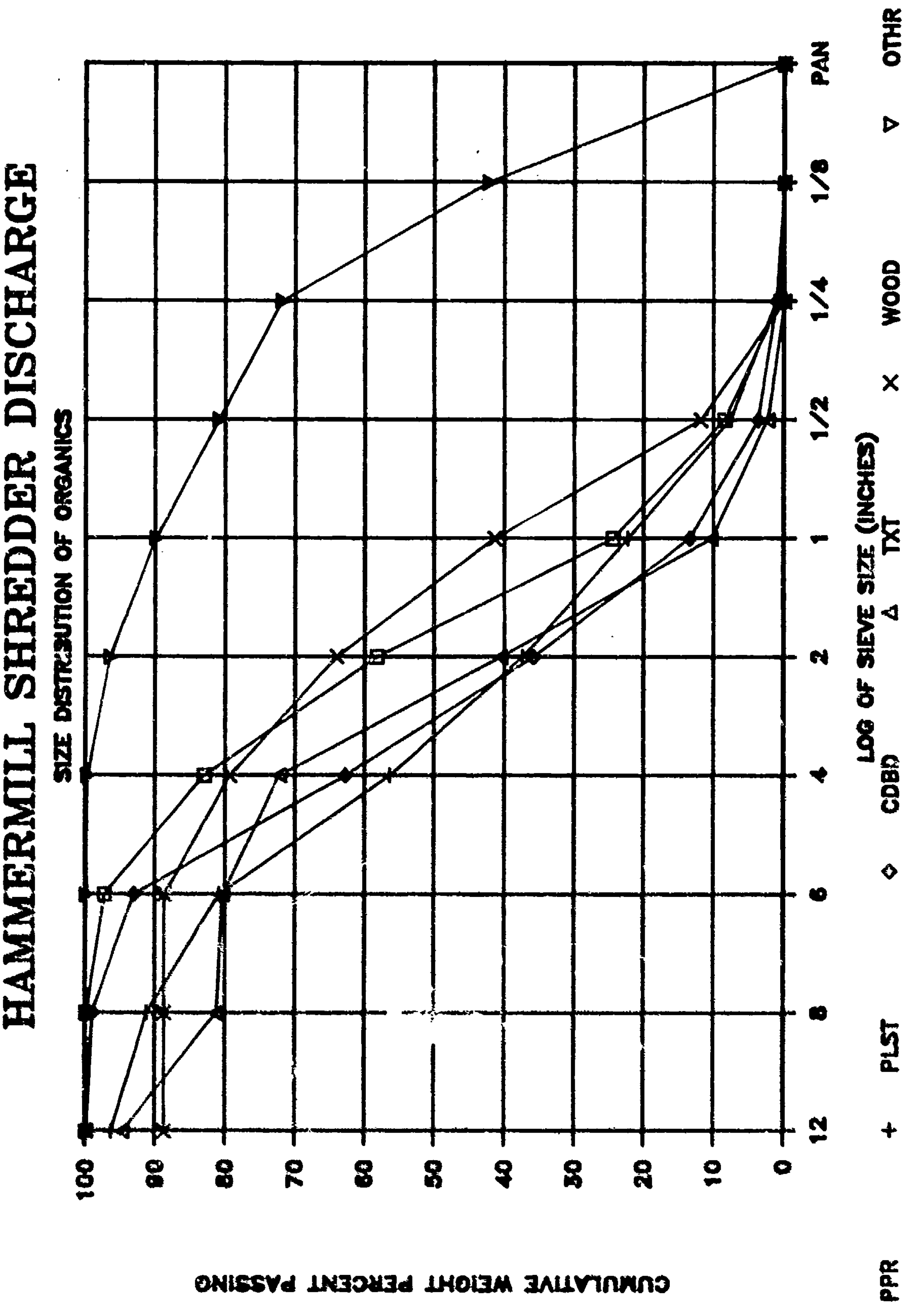

HAMMERMILL SHREDDER DISCHARGE
SIZE DISTRIBUTION BY MAJOR COMPONENT
CUMULATIVE WEIGHT PERCENT PASSING
100
90
80
70
60
50
40
30
20
10
0
12
8
6
4
2
1
1/2
1/4
1/8
PAN
LOG OF SIEVE SIZE (INCHES)
ORG
GLASS
INERT
FE
NFM
TTL

Figure I-2


HAMMERMILL SHREDDER DISCHARGE
SIZE DISTRIBUTION OF ORGANICS
CUMULATIVE WEIGHT PERCENT PASSING
100
90
80
70
60
50
40
30
20
10
0
12
8
6
4
2
1
1/2
1/4
1/8
PAN
LOG OF SIEVE SIZE (INCHES)
PPR
PLST
CDBD
TXT
WOOD
OTHR

APPENDIX J

DATA SHEETS:
REPAIR HOURS, MANHOURS, AND COSTS

DATE	MAJOR MAINTENANCE ACTIONS ======= SHEAR SHREDDER ===============				MAJOR MAINTENANCE ACTIONS ======= HAMMERMILL #2 ===============				MAJOR MAINTENANCE ACTIONS ======= HAMMERMILL #3 ===============			
	DESCRIPTION	TIME	MAN-HOURS	COSTS	DESCRIPTION	HOURS	MAN-HOURS	COSTS	DESCRIPTION	HOURS	MAN-HOURS	COSTS
02-Jan-84												
03-Jan-84	INSTALL NEW SHAFTS	9			REPLACE 6 HAMMERS	0.5	1	54	REPLACE 6 HAMMERS	0.5	1	54
04-Jan-84	INSTALL NEW SHAFTS	9							REPLACE 6 HAMMERS	0.5	1	54
05-Jan-84					REPLACE LINERS	10	40	3220	REPLACE LINERS	12	42	2280
06-Jan-84					REPLACE LINERS				REPLACE LINERS			
07-Jan-84												
08-Jan-84												
09-Jan-84					REPLACE LINERS				REPLACE LINERS			
10-Jan-84					REPLACE LINERS				REPLACE LINERS			
11-Jan-84					REPLACE LINERS				REPLACE LINERS			
12-Jan-84	REPLACE #1 FILTER	0.3	0.5	70	REPLACE 15 HAMMERS	1	2	135	REPLACE 9 HAMMERS	0.5	1	81
13-Jan-84												
14-Jan-84												
15-Jan-84												
16-Jan-84												
17-Jan-84	REPLACE #6 FILTER	0.3	0.5	70								
18-Jan-84												
19-Jan-84												
20-Jan-84												
21-Jan-84												
22-Jan-84									230			
23-Jan-84					REPLACE 9 HAMMERS	0.5	1	81	REPLACE 6 HAMMERS	0.5	1	54
24-Jan-84												
25-Jan-84												
26-Jan-84												
27-Jan-84												
28-Jan-84												
29-Jan-84												
30-Jan-84												
31-Jan-84									550			
01-Feb-84					REPLACE 6 HAMMERS	0.5	1	54	REPLACE 15 HAMMERS	1	2	135
02-Feb-84												
03-Feb-84	REPLACE HYD. MOTOR				REPLACE 6 HAMMERS	0.5	1	54				
04-Feb-84												
05-Feb-84												
06-Feb-84	REPLACE HYD. MOTOR											
07-Feb-84	REPLACE HYD. MOTOR											
08-Feb-84	# & #3 FILTER	0.3	0.5	70	REPLACE 6 HAMMERS	0.5	1	54	REPLACE 3 HAMMERS	0.5	1	27
09-Feb-84	REPLACE #1 FILTER	0.3	0.5	70								
10-Feb-84	43.5											
11-Feb-84												
12-Feb-84												
13-Feb-84												
14-Feb-84												
15-Feb-84									425			
16-Feb-84					REPLACE 18 HAMMERS	1	2	162	REPLACE 18 HAMMERS	1	2	162
17-Feb-84	REPLACE #2 FILTER	0.3	0.5	70								
18-Feb-84												
19-Feb-84												
20-Feb-84												
21-Feb-84	REPLACE #2&6 FLTRS	0.5	1	140	REPLACE 6 HAMMERS	0.5	1	54	REPLACE 6 HAMMERS	0.5	1	54
22-Feb-84	REPLACE #1 FILTER	0.3	0.5	70								

DATE	MAJOR MAINTENANCE ACTIONS ======= SHEPP SHREDDER =======				MAJOR MAINTENANCE ACTIONS ======= HAMMERMILL #2 =======				MAJOR MAINTENANCE ACTIONS ======= HAMMERMILL #3 =======			
	DESCRIPTION	TIME	MANHOURS	COSTS	DESCRIPTION	HOURS	MANHOURS	COSTS	DESCRIPTION	HOURS	MANHOURS	COSTS
23-Feb-84					REPLACE 6 HAMMERS	0.5	1	54	REPLACE 6 HAMMERS	0.5	1	54
24-Feb-84												
25-Feb-84												
26-Feb-84												
27-Feb-84												
28-Feb-84												
29-Feb-84												
01-Mar-84												
02-Mar-84												
03-Mar-84												
04-Mar-84												
05-Mar-84	TGHTN SHFT COLLAR	0.3	0.5	0								
06-Mar-84												
07-Mar-84	REPLACE #3 FILTER	0.3	0.5	70	REPLACE 15 HAMMERS	0.5	1	135	REPLACE 15 HAMMERS	0.5	1	135
08-Mar-84												
09-Mar-84	REPLACE #1 FILTER	0.3	0.5	70								
10-Mar-84	3930											
11-Mar-84												
12-Mar-84	REPLACE #6 FILTER	0.3	0.5	70								
13-Mar-84												
14-Mar-84									REPLACE 9 HAMMERS	0.5	1	81
15-Mar-84												
16-Mar-84												
17-Mar-84												
18-Mar-84												
19-Mar-84												
20-Mar-84									REPLACE 9 HAMMERS	0.5	1	81
21-Mar-84					REPLACE 18 HAMMERS	1	2	162				
22-Mar-84	REPLACE #2 FILTER	0.3	0.5	70								
23-Mar-84												
24-Mar-84												
25-Mar-84												
26-Mar-84												
27-Mar-84					REPLACE 6 HAMMERS	0.5	1	54	REPLACE 12 HAMMERS	0.5	1	108
28-Mar-84												
29-Mar-84	REPLACE #4 FILTER	0.3	0.5	70	REPLACE 6 HAMMERS	0.5	1	54				
30-Mar-84												
31-Mar-84												
01-Apr-84												
02-Apr-84												
03-Apr-84												
04-Apr-84									REPLACE 9 HAMMERS	1	2	81
05-Apr-84												
06-Apr-84					REPLACE 9 HAMMERS	0.5	1	81				
07-Apr-84												
08-Apr-84												
09-Apr-84	CHANGE CUTTERS	8	40	24200								
10-Apr-84	18512											
11-Apr-84												
12-Apr-84												
13-Apr-84												
14-Apr-84												

DATE	MAJOR MAINTENANCE ACTIONS ======= SHEAR SHREDDER ======= DESCRIPTION	TIME	MAN-HOURS	COSTS	MAJOR MAINTENANCE ACTIONS ======= HAMMERMILL #2 ======= DESCRIPTION	HOURS	MAN-HOURS	COSTS	MAJOR MAINTENANCE ACTIONS ======= HAMMERMILL #3 ======= DESCRIPTION	HOURS	MAN-HOURS	COSTS
15-Apr-84												
16-Apr-84	BACK IN OPERATION											
17-Apr-84												
18-Apr-84												
19-Apr-84					—							
20-Apr-84												
21-Apr-84												
22-Apr-84												
23-Apr-84												
24-Apr-84												
25-Apr-84												
26-Apr-84												
27-Apr-84					REPLACE 6 HAMMERS	0.5	0.5	54	REPLACE 9 HAMMERS	1	[illegible]	81
28-Apr-84					(estimated date)				(estimated date)			
29-Apr-84												
30-Apr-84									REPLACE 6 HAMMERS	0.5	0.5	54
01-May-84									REPLACE 6 HAMMERS	0.5	0.5	54
02-May-84												
03-May-84	REPLACE #1 FILTER	0.3	0.5	72								
04-May-84												
05-May-84												
06-May-84												
07-May-84												
08-May-84												
09-May-84					REPLACE 15 HAMMERS	1	2	135				
10-May-84									REPLACE 15 HAMMERS	1	2	135
11-May-84												
12-May-84												
13-May-84												
14-May-84	REPLACE #1 FILTER	0.3	0.5	70								
15-May-84	REPLACE #6 FILTER	0.3	0.5	70								
16-May-84					REPLACE 15 HAMMERS	1	2	135	REPLACE 6 HAMMERS	0.5	0.5	54
17-May-84					(estimated date)				(estimated date)			
18-May-84												
19-May-84												
20-May-84												
21-May-84												
22-May-84									REPLACE 9 HAMMERS	0.5	1	81
23-May-84					REPLACE 6 HAMMERS	0.5	0.5	54	(estimated date)			
24-May-84					(estimated date)							
25-May-84	REPLACE #2 FILTER	0.3	0.5	70	—							
26-May-84												
27-May-84												
28-May-84												
29-May-84	REPLACE #4 FILTER	0.3	0.5	72								
30-May-84	11335				REPLACE 9 HAMMERS	0.5	1	81	REPLACE 15 HAMMERS	1	2	135
31-May-84					(estimated date)				(estimated date)			
01-Jun-84												
02-Jun-84												
03-Jun-84												
04-Jun-84												
05-Jun-84												

DATE	MAJOR MAINTENANCE ACTIONS C-SIDE SHREDDER DESCRIPTION	TIME	MAN-HOURS	COSTS	MAJOR MAINTENANCE ACTIONS HAMMERMILL #1 DESCRIPTION	HOURS	MAN-HOURS	COSTS	MAJOR MAINTENANCE ACTIONS HAMMERMILL #2 DESCRIPTION	HOURS	MAN-HOURS	COSTS
06-Jun-84					REPLACED 5 HAMMERS	0.5	0.5	54	REPLACE 15 HAMMERS	1	2	135
07-Jun-84					REPLACED 8 HAMMERS	0.5	1	72				
08-Jun-84												
09-Jun-84												
10-Jun-84												
11-Jun-84	REPLACE #1 FILTER	0.3	0.5	70								
12-Jun-84	5516											
13-Jun-84					REPLACED 9 HAMMERS	0.5	1	81				
14-Jun-84												
15-Jun-84	13857 tons											
16-Jun-84	CUTTER CHANGE	4	42	24222								
17-Jun-84												
18-Jun-84												
19-Jun-84												
20-Jun-84												
21-Jun-84												
22-Jun-84												
23-Jun-84												
24-Jun-84	BACK IN OPERATION											
25-Jun-84	REPLACE #2 FILTER	0.3	0.5	70								
26-Jun-84												
27-Jun-84												
28-Jun-84	REPLACE HIGH FLTRS	0.5	0.5	140								
29-Jun-84												
30-Jun-84												
01-Jul-84												
02-Jul-84												
03-Jul-84												
04-Jul-84												
05-Jul-84												
06-Jul-84	REPLACE #5 FILTER	0.3	0.5	70								
07-Jul-84												
08-Jul-84												
09-Jul-84												
10-Jul-84												
11-Jul-84												
12-Jul-84												
13-Jul-84					FIRE				FIRE			
14-Jul-84												
15-Jul-84												
16-Jul-84					STILL FIRE				STILL FIRE			
17-Jul-84												
18-Jul-84	REPLACE HIGH FLTRS	0.5	0.5	140								
19-Jul-84												
20-Jul-84												
21-Jul-84												
22-Jul-84												
23-Jul-84												
24-Jul-84												
25-Jul-84												
26-Jul-84												
27-Jul-84												

DATE	MAJOR MAINTENANCE ACTIONS ======= SHEAR SHREDDER ==============				MAJOR MAINTENANCE ACTIONS ======= HAMMERMILL #2 ==============				MAJOR MAINTENANCE ACTIONS ======= HAMMERMILL #3 ==============			
	DESCRIPTION	TIME	MAN-HOURS	COSTS	DESCRIPTION	HOURS	MAN-HOURS	COSTS	DESCRIPTION	HOURS	MAN-HOURS	COSTS
28-Jul-84												
29-Jul-84												
30-Jul-84												
31-Jul-84												
01-Aug-84												
02-Aug-84												
03-Aug-84	REPLACE #6 FILTER	0.3	0.5	70								
04-Aug-84												
05-Aug-84												
06-Aug-84												
07-Aug-84												
08-Aug-84	REPLACE #1 FILTER	0.3	0.5	70								
09-Aug-84												
10-Aug-84												
11-Aug-84												
12-Aug-84												
13-Aug-84												
14-Aug-84												
15-Aug-84	REPLACE #4 FILTER	0.3	0.5	70								
16-Aug-84												
17-Aug-84												
18-Aug-84												
19-Aug-84												
20-Aug-84												
21-Aug-84												
22-Aug-84	REPLACE #[illegible] FILTER	[illegible]	[illegible]	[illegible]								
23-Aug-84	REPLACE #[illegible] FILTER	0.3	0.5	[illegible]								
24-Aug-84												
25-Aug-84												
26-Aug-84												
27-Aug-84												
28-Aug-84												
29-Aug-84												
30-Aug-84												
31-Aug-84												
01-Sep-84	[illegible]											
02-Sep-84												
03-Sep-84	[illegible] tons											
04-Sep-84	CUTTER CHANGE	8	[illegible]	[illegible]								
05-Sep-84	BACK IN OPERATION											
06-Sep-84												
07-Sep-84												
08-Sep-84												
09-Sep-84												
10-Sep-84												
11-Sep-84	REPLACE # [illegible] FILTER	[illegible]	0.5	[illegible]								
12-Sep-84												
13-Sep-84												
14-Sep-84												
15-Sep-84												
16-Sep-84												
17-Sep-84												

DATE	MAJOR MAINTENANCE ACTIONS ======= SHEAR SHREDDER =============== DESCRIPTION	TIME	MAN-HOURS	COSTS	MAJOR MAINTENANCE ACTIONS ======= HAMMERMILL #2 =============== DESCRIPTION	HOURS	MANHOURS	COSTS	MAJOR MAINTENANCE ACTIONS ======= HAMMERMILL #3 =============== DESCRIPTION	HOURS	MANHOURS	COSTS
18-Sep-84												
19-Sep-84												
20-Sep-84												
DAYS												
WEEKS												
AVERAGE		1.51	4.22	2320.00		1.02	2.85	219.74		1.27	2.93	221.30
MAX VALUE		9.00	40.00	********		10.00	40.00	3200.00		12.00	40.00	3200.00
	SUM	40.70	91.00	********		23.50	65.50	5054.00		24.50	57.50	5092.00
VARIANCE												
STD.DEV.												
DEV/AVG												
SUM		40.7	91	49540		23.5	65.5	5054		24.5	57.5	5092

Appendix K

LIFE-CYCLE COST ANALYSES
CHARLESTON COUNTY, SC SWRC

FILE: NAVY31

ABSTRACT PRESENT VALUE COSTS PER TON TO SHRED MSW	CHARLESTON FOR SHEAR SHREDDER	ANALYSIS PREFERRED	FOR HAMMER MILLS	ANALYSIS PREFERRED
PV COST/TON MSW INCLUDING CAPITAL INVESTMENT:	$2.34	NO	$4.62	NO
PV COST/TON MSW EXCLUDING CAPITAL INVESTMENT (CASE OF SUNK CAPITAL COSTS):	$1.60	YES	$2.46	YES

	UNITS	SUGGESTED BY P442	CHARLESTON VALUES USED BY WTE: FOR SHEAR SHREDDER	FROM	FOR HAMMER MILLS	FROM
ECONOMIC LIVES:						
ADP EQUIPMENT	YEARS	8				
BUILDINGS						
PERMANENT	YEARS	25	25		25	
SEMI-PERMANENT, NON-WOOD	YEARS	25				
SEMI-PERMANENT, WOOD	YEARS	20				
TEMPORARY OR REHABILITATED	YEARS	15				
OPERATING EQUIPMENT	YEARS	10	10		10	
UTILITIES, PLANTS, UTILITY						
DISTRIBUTION SYSTEMS	YEARS	25				
TIME VALUE OF MONEY	PCT		10.0%		10.0%	
AVERAGE INFLATION RATE	PCT		5.0%		5.0%	
BASIC WAGERATE						
OPERATING	$/HR		$7.50		$7.50	
MAINTENANCE	$/HR		$5.25		$5.25	
ADMINISTRATIVE	$/HR		$10.50		$10.50	
BURDENING FACTOR (OH,T,F)	NONE		1.25	E	1.25	E
COST OF ELECTRICITY	$/KWH		$0.06	T	$0.06	T
COST OF MATL, PER BLADES/						
HAMMERS CHANGE	$/CHG		$24,000	A	$9.00	A
COST FOR UNSHREDDABLE DISPOSAL	$/TON		$1.00	T	$1.00	T
VALUE OF RDF	$/TON		$0		$0	

E=EXPERIENCE
M=MEANS
M*E=MEANS AND EXPERIENCE
C=CHEM ENG MAGAZINE
C*E=CHEM E MAG AND EXPERIENCE
CH=12/31/81 CHARLESTON COUNTY REPORT
T=TYPICAL VALUE
A=ACTUAL DERIVED FROM DATA
AB=ALLEN BRADLEY CATALOG
S=SIMULATION TO GIVE REPRESENTATIVE RESULTS
TX xX=TABLE X-XX FROM THIS REPORT

RESERVED

	UNITS		FOR SHEAR SHREDDER	FROM	FOR HAMMER MILLS	FROM
CONSTRUCTION COST						
EQUIPMENT AND MATERIAL						
SHREDDER	$		$300,000	E	$87,000	E
CONVEYORS	$		$214,000	E	$214,000	E
CHUTES/TRANSITIONS	$		$10,000	T	$10,000	T
EXPLOSION VENTS	$		$0	E	$27,210	CH*E
DUST CONTROL	$		$30,000	E	$30,000	[illegible]
MOTOR CONTROL CENTER	$		$13,450	AB	$13,110	AB
ACCESS PROVISIONS	$		INCLUDED		INCLUDED	

76	CONTROLS	$		$1,240	M*E	$620	M*E
77	SPARES	$		$30,000	A	$340	A
78	BLAST WALLS	$		$0	E	$18,000	M*E
79	FOUNDATION	$		$4,750	C*E	$6,220	C*E
80	STRUCTURAL SUPPORTS	$		$4,000	E	$4,000	E
81	VIBRATION ISOLATION	$		$0	E	$2,000	E
82	TOTAL E&M	$		$607,440		$412,500	
83			------				
84			FIELD				
85			INST				
86	INSTALLATION		FACTOR				
87	SHREDDER	$	1.12	$36,000	C*E	$10,440	C*E
88	CONVEYORS	$	1.64	$136,960	C*E	$136,960	C*E
89	CHUTES/TRANSITIONS	$	2.00	$10,000	C*E	$10,000	C*E
90	EXPLOSION VENTS	$	1.80	$0	E	$21,770	CH*E
91	DUST CONTROL	$	1.69	$20,700	C*E	$20,700	C*E
92	MOTOR CONTROL CENTER	$	1.20	$2,690	C*E	$2,620	C*E
93	ACCESS PROVISIONS	$	1.70	$0	E	$0	E
94	CONTROLS	$	N/A	$513	M*E	$257	M*E
95	SPARES	$	1.00	$0		$0	
96	BLAST WALLS	$	N/A	$0	M*E	$32,400	M*E
97	FOUNDATION	$	N/A	$7,780	C*E	$10,170	C*E
98	STRUCTURAL SUPPORTS	$	1.80	$3,200	E	$3,200	E
99	VIBRATION ISOLATION	$	1.50	$0	E	$1,000	E
100	TOTAL INSTALLATION	$	------	$217,843		$249,520	
101	TOTAL EQMT, MATL, LABOR	$		$825,280		$662,020	
102	ENGINEERING/CONST SUPERVISION	%INST	12%	$99,030		$79,440	
103	MANAGEMENT RESERVE	%INST	15%	$138,650		$111,220	
104	TOTAL CONST COST	$		$1,062,960		$852,680	
105	FINANCING COSTS	%TOT	25%	$265,740		$213,170	
106	CAPITAL COST DURING CONST	$		$1,328,700		$1,065,850	
107	FOR A ONE YEAR CONST PERIOD,						
108	CAPITAL COST PER QTR IS:			$332,180		$266,460	
109							
110	PV AT DAY 0 OF CONST						
111	PHASE (APPLIES TO NAVY CASE) IS.			$1,249,650		$1,002,420	
112							
113	MAJOR EQUIPMENT REPLACEMENT COST	$		$737,660		$499,100	
114							
115	MAXIMUM PRACTICAL PROJECT LIFE	YEARS		20		20	
116							
117							
118	NUMBER OF EQMT REPLMTS IN LIFE	EACH		1		1	
119							
120	PV AT CONST DAY 0 EQUIVALENT TO FUTURE AMOUNT						
121	TO REPLACE EQMT 1ST TIME			$442,200		$299,190	
122							
123	PV AT CONST DAY 0 EQUIVALENT TO FUTURE AMOUNT						
124	TO REPLACE EQMT 2D TIME			$277,710		$187,900	
125							
126	PV AT CONST DAY 0 EQUIVALENT TO FUTURE AMOUNT						
127	TO REPLACE EQMT 3D TIME			$174,430		$118,000	
128							
129	PV OF MAJOR REPLACEMENTS						
130	AT CONST DAY 0 (APPLIES TO NAVY CASE):			$442,200		$299,190	
131							
132	FOR THE CHARLESTON CASE CAPITAL						
133	COSTS ASSOCIATED WITH ORIGINAL CONSTRUCTION						
134	ARE ASSUMED TO BE SUNK COSTS AND DAY 0 FOR THE						
135	PRESENT VALUE ANALYSIS IS DAY 0 OF OPERATIONS						
136	(NOT DAY 0 OF CONSTRUCTION AS IS THE NAVY CASE).						
137							
138	PV OF MAJOR REPLACEMENTS						
139	AT OPERATIONS DAY 0 (CHLSTN CASE):			$463,260		$313,440	
140							
141							
142							
143							
144							
145	OPERATING REQMTS						
146	ELECTRIC POWER						
147	SHREDDER DRIVE	KW/TON		3.14	T2-11	9.14	T2-11
148	LABOR OPERATING ONLY	MH/TON		0.0352	T2-13	0.1327	T2-13
149	LABOR ADMINISTRATIVE	MH/TON		0.0032	T2-13	0.0129	T2-13
150	TOTAL ANNUAL COST	$/YR		$40,070		$41,830	

151						
152	MAINTENANCE					
153	LABOR	MH/TON	0.0026	T2-13	0.0083	T2-13
154	TOTAL ANNUAL COST	$/YR	$1,220		$1,160	
155						
156	REPAIR					
157	LABOR	MH/TON	0.0028	T2-14	0.0082	T2-14
158	PARTS	$/TON	$1.51	T2-14	$0.63	T2-14
159	TOTAL ANNUAL COST	$/YR	$109,279		$14,579	
160						
161	THROUGHPUT/CAPACITY FACTOR/AVAILABILITY					
162						
163	AVG INFEED PER YEAR	TONS	71500	T2-7	21320	T2-7
164						
165	UNSHREDDABLES					
166	AS PERCENT OF INFEED	PCT	0.25%	T2-2	15.33%	T2-2
167	TOTAL ANNUAL DISPOSAL COST	$/TON	$179		$3,268	
168						
169	RDF					
170	ANNUAL PRODUCTION	TONS	71321		18052	
171	TOTAL ANNUAL VALUE	$/YR	$0		$0	
172						
173	SUMMARY, OVER OPERATIONAL LIFE EQUAL TO YEARS=		20		20	
174	AND:					
175	================================		==========	========	==========	========
176	ALL PV'S BASED ON DAY 0 CONSTRUCTION					
177	WHICH WE BELIEVE IS BEST APPLIED					
178	TO THE NAVY CASE:					
179	PV AT DAY 0 COST OF ORIGINAL CAPITAL		$1,249,650		$1,002,420	
180	PV DAY 0 COST OF MAJOR EQMT REPLACEMENT		$442,200		$299,190	
181	TOTAL PV OF O&M, REPAIR AND DISPOSAL COSTS		1.66E+06		6.70E+05	
182						
183	TOTAL PRESENT VALUE OF RDF OVER OPTG LIFE		$0		$0	
184						
185	TOTAL NET PV COST PER TON MSW		$2.34		$4.62	
186	================================		==========	========	==========	========
187	ALL PV'S BASED ON DAY 0 OPERATIONS					
188	WHICH WE BELIEVE IS BEST APPLIED TO THE					
189	CHARLESTON CASE WHERE CAPITAL COSTS					
190	ARE ASSUMED SUNK:					
191	PV AT DAY 0 COST OF ORIGINAL CAPITAL		$0		$0	
192	PV DAY 0 COST OF MAJOR EQMT REPLACEMENT		$463,260		$313,440	
193	TOTAL PV OF O&M, REPAIR AND DISPOSAL COSTS		1.83E+06		7.37E+05	
194						
195	TOTAL PRESENT VALUE OF RDF OVER OPTG LIFE, $		$0		$0	
196						
197	TOTAL NET PV COST PER TON MSW		$1.60		$2.46	
198	================================		==========	========	==========	========
199						
200						
201	FOR INFLATION OF 5.00% AVERAGE PER YEAR:					
202	OPERATING, MAINT, DISPOSAL, REPAIR COST					
203			0	0		
204	1 ST YEAR OPTG, 2D YR AFTER CONST START		1.51E+05	150748	6.08E+04	60837
205	2 ND YEAR		1.58E+05	158285	6.39E+04	63879
206	3 RD YEAR		1.66E+05	166199	6.71E+04	67073
207	4 AND SO ON...		1.75E+05	174509	7.04E+04	70427
208	5		1.83E+05	183235	7.39E+04	73948
209	6		1.92E+05	192396	7.76E+04	77645
210	7		2.02E+05	202016	8.15E+04	81528
211	8		2.12E+05	212117	8.56E+04	85604
212	9		2.23E+05	222723	8.99E+04	89884
213	10		2.34E+05	233859	9.44E+04	94379
214	11		2.46E+05	245552	9.91E+04	99097
215	12		2.58E+05	257829	1.04E+05	104052
216	13		2.71E+05	270721	1.09E+05	109255
217	14		2.84E+05	284257	1.15E+05	114718
218	15		2.98E+05	298470	1.20E+05	120454
219	16		3.13E+05	313393	1.26E+05	126476
220	17		3.29E+05	329063	1.33E+05	132800
221	18		3.46E+05	345516	1.39E+05	139440
222	19		3.63E+05	362792	1.46E+05	146412
223	20		3.81E+05	380932	1.54E+05	153733
224	21		4.00E+05	0	1.61E+05	0
225	22		4.20E+05	0	1.69E+05	0

226	23	4.41E+05	0	1.78E+05	0
227	24	4.63E+05	0	1.87E+05	0
228	25	4.86E+05	0	1.96E+05	0
229	26	5.10E+05	0	2.06E+05	0
230	27	5.36E+05	0	2.16E+05	0
231	28	5.63E+05	0	2.27E+05	0
232	29	5.91E+05	0	2.38E+05	0
233	30	6.20E+05	0	2.50E+05	0
234	31	6.52E+05	0	2.63E+05	0
235	32	6.84E+05	0	2.76E+05	0
236	33	7.18E+05	0	2.90E+05	0
237	34	7.54E+05	0	3.04E+05	0
238	35	7.92E+05	0	3.20E+05	0
239	36	8.32E+05	0	3.36E+05	0
240	37	8.73E+05	0	3.52E+05	0
241	38	9.17E+05	0	3.70E+05	0
242	39	9.63E+05	0	3.88E+05	0
243	40	1.01E+06	0	4.08E+05	0
244	41	1.06E+06	0	4.28E+05	0
245	42	1.11E+06	0	4.50E+05	0
246	43	1.17E+06	0	4.72E+05	0
247	44	1.23E+06	0	4.96E+05	0
248	45	1.29E+06	0	5.21E+05	0
249	46	1.35E+06	0	5.47E+05	0
250	47	1.42E+06	0	5.74E+05	0
251	48	1.49E+06	0	6.03E+05	0
252	49	1.57E+06	0	6.33E+05	0
253	50	1.65E+06	0	6.64E+05	0
254	51	1.73E+06	0	6.98E+05	0
255	52	1.82E+06	0	7.33E+05	0
256	53	1.91E+06	0	7.69E+05	0
257	54	2.00E+06	0	8.08E+05	0
258	55	2.10E+06	0	8.48E+05	0
259	56	2.21E+06	0	8.90E+05	0
260	57	2.32E+06	0	9.35E+05	0
261	58	2.43E+06	0	9.82E+05	0
262	59	2.55E+06	0	1.03E+06	0
263	60	2.68E+06	0	1.08E+06	0
264	61	2.82E+06	0	1.14E+06	0
265	62	2.96E+06	0	1.19E+06	0
266	63	3.10E+06	0	1.25E+06	0
267	64	3.26E+06	0	1.32E+06	0
268	65	3.42E+06	0	1.38E+06	0
269	66	3.59E+06	0	1.45E+06	0
270	67	3.77E+06	0	1.52E+06	0
271	68	3.96E+06	0	1.60E+06	0
272	69	4.16E+06	0	1.68E+06	0
273	70	4.37E+06	0	1.76E+06	0
274	71	4.59E+06	0	1.85E+06	0
275	72	4.82E+06	0	1.94E+06	0
276	73	5.06E+06	0	2.04E+06	0
277	74	5.31E+06	0	2.14E+06	0
278	75	5.58E+06	0	2.25E+06	0
279	76	5.85E+06	0	2.36E+06	0
280	77	6.15E+06	0	2.48E+06	0
281	78	6.45E+06	0	2.60E+06	0
282	79	6.78E+06	0	2.73E+06	0
283	80	7.12E+06	0	2.87E+06	0
284	81	7.47E+06	0	3.02E+06	0
285	82	7.84E+06	0	3.17E+06	0
286	83	8.24E+06	0	3.32E+06	0
287	84	8.65E+06	0	3.49E+06	0
288	85	9.08E+06	0	3.66E+06	0
289	86	9.54E+06	0	3.85E+06	0
290	87	1.00E+07	0	4.04E+06	0
291	88	1.05E+07	0	4.24E+06	0
292	89	1.10E+07	0	4.45E+06	0
293	90	1.16E+07	0	4.68E+06	0
294	91	1.22E+07	0	4.91E+06	0
295	92	1.28E+07	0	5.16E+06	0
296	93	1.34E+07	0	5.41E+06	0
297	94	1.41E+07	0	5.69E+06	0
298	95	1.48E+07	0	5.97E+06	0
299	96	1.55E+07	0	6.27E+06	0
300	97	1.63E+07	0	6.58E+06	0

301	98	1.71E+07	0	6.91E+06	0
302	99	1.80E+07	0	7.26E+06	0
303	100	1.89E+07	0	7.62E+06	0
304					
305					
306	FOR INFLATION OF 5.00% AVERAGE PER YEAR:				
307	RDF VALUE	$0	0		
308	1 ST YEAR OPERATING, 2D YEAR AFTER DAY 0	0.00E+00	0	0.00E+00	0
309	2 ND YEAR	0.00E+00	0	0.00E+00	0
310	3 RD YEAR	0.00E+00	0	0.00E+00	0
311	4 AND SO ON...	0.00E+00	0	0.00E+00	0
312	5	0.00E+00	0	0.00E+00	0
313	6	0.00E+00	0	0.00E+00	0
314	7	0.00E+00	0	0.00E+00	0
315	8	0.00E+00	0	0.00E+00	0
316	9	0.00E+00	0	0.00E+00	0
317	10	0.00E+00	0	0.00E+00	0
318	11	0.00E+00	0	0.00E+00	0
319	12	0.00E+00	0	0.00E+00	0
320	13	0.00E+00	0	0.00E+00	0
321	14	0.00E+00	0	0.00E+00	0
322	15	0.00E+00	0	0.00E+00	0
323	16	0.00E+00	0	0.00E+00	0
324	17	0.00E+00	0	0.00E+00	0
325	18	0.00E+00	0	0.00E+00	0
326	19	0.00E+00	0	0.00E+00	0
327	20	0.00E+00	0	0.00E+00	0
328	21	0.00E+00	0	0.00E+00	0
329	22	0.00E+00	0	0.00E+00	0
330	23	0.00E+00	0	0.00E+00	0
331	24	0.00E+00	0	0.00E+00	0
332	25	0.00E+00	0	0.00E+00	0
333	26	0.00E+00	0	0.00E+00	0
334	27	0.00E+00	0	0.00E+00	0
335	28	0.00E+00	0	0.00E+00	0
336	29	0.00E+00	0	0.00E+00	0
337	30	0.00E+00	0	0.00E+00	0
338	31	0.00E+00	0	0.00E+00	0
339	32	0.00E+00	0	0.00E+00	0
340	33	0.00E+00	0	0.00E+00	0
341	34	0.00E+00	0	0.00E+00	0
342	35	0.00E+00	0	0.00E+00	0
343	36	0.00E+00	0	0.00E+00	0
344	37	0.00E+00	0	0.00E+00	0
345	38	0.00E+00	0	0.00E+00	0
346	39	0.00E+00	0	0.00E+00	0
347	40	0.00E+00	0	0.00E+00	0
348	41	0.00E+00	0	0.00E+00	0
349	42	0.00E+00	0	0.00E+00	0
350	43	0.00E+00	0	0.00E+00	0
351	44	0.00E+00	0	0.00E+00	0
352	45	0.00E+00	0	0.00E+00	0
353	46	0.00E+00	0	0.00E+00	0
354	47	0.00E+00	0	0.00E+00	0
355	48	0.00E+00	0	0.00E+00	0
356	49	0.00E+00	0	0.00E+00	0
357	50	0.00E+00	0	0.00E+00	0
358	51	0.00E+00	0	0.00E+00	0
359	52	0.00E+00	0	0.00E+00	0
360	53	0.00E+00	0	0.00E+00	0
361	54	0.00E+00	0	0.00E+00	0
362	55	0.00E+00	0	0.00E+00	0
363	56	0.00E+00	0	0.00E+00	0
364	57	0.00E+00	0	0.00E+00	0
365	58	0.00E+00	0	0.00E+00	0
366	59	0.00E+00	0	0.00E+00	0
367	60	0.00E+00	0	0.00E+00	0
368	61	0.00E+00	0	0.00E+00	0
369	62	0.00E+00	0	0.00E+00	0
370	63	0.00E+00	0	0.00E+00	0
371	64	0.00E+00	0	0.00E+00	0
372	65	0.00E+00	0	0.00E+00	0
373	66	0.00E+00	0	0.00E+00	0
374	67	0.00E+00	0	0.00E+00	0
375	68	0.00E+00	0	0.00E+00	0

Appendix L

LIFE-CYCLE COST ANALYSES
50 TPD NAVY SHREDDING STATION

FILE: NAVY41

ABSTRACT PRESENT VALUE COSTS PER TON TO SHRED MSW	50 TPD NAVY: FOR SHEAR SHREDDER	ANALYSIS PREFERRED	FOR HAMMER MILLS	ANALYSIS PREFERRED
PV COST/TON MSW INCLUDING CAPITAL INVESTMENT:	$4.27	YES	$4.36	YES
PV COST/TON MSW EXCLUDING CAPITAL INVESTMENT (CASE OF SUNK CAPITAL COSTS):	$0.44	NO	$1.12	NO

LINE	UNITS	SUGGESTED BY P442	50 TPD NAVY, VALUES USED BY WTE: FOR SHEAR SHREDDER	FROM	FOR HAMMER MILLS	FROM
ECONOMIC LIVES:						
ADP EQUIPMENT	YEARS	8				
BUILDINGS						
PERMANENT	YEARS	25	25		25	
SEMI-PERMANENT, NON-WOOD	YEARS	25				
SEMI-PERMANENT, WOOD	YEARS	20				
TEMPORARY OR REHABILITATED	YEARS	15				
OPERATING EQUIPMENT	YEARS	10	12		12	
UTILITIES, PLANTS, UTILITY						
DISTRIBUTION SYSTEMS	YEARS	25				
TIME VALUE OF MONEY	PCT		10.0%		10.0%	
AVERAGE INFLATION RATE	PCT		5.0%		5.0%	
BASIC WAGERATE						
OPERATING	$/HR		$7.50		$7.50	
MAINTENANCE	$/HR		$5.25		$5.25	
ADMINISTRATIVE	$/HR		$10.50		$10.50	
BURDENING FACTOR (OH,T,F)	NONE		1.25	E	1.25	E
COST OF ELECTRICITY	$/KWH		$0.06	T	$0.06	T
COST OF MATL, PER BLADES/						
HAMMERS CHANGE	$/CHG		$24,000	A	$9.00	A
COST FOR UNSHREDDOABLE DISPOSAL	$/TON		$8.60	T	$8.60	T
VALUE OF RDF	$/TON		$5		$5	

E=EXPERIENCE
M=MEANS
M*E=MEANS AND EXPERIENCE
C=CHEM ENG MAGAZINE
C*E=CHEM E MAG AND EXPERIENCE
CH=12/31/81 CHARLESTON COUNTY REPORT
T=TYPICAL VALUE
A=ACTUAL DERIVED FROM DATA
AB=ALLEN BRADLEY CATALOG
S=SIMULATION TO GIVE REPRESENTATIVE RESULTS
TX-XX=TABLE X-XX FROM THIS REPORT

RESERVED

		FOR SHEAR SHREDDER	FROM	FOR HAMMER MILLS	FROM
CONSTRUCTION COST					
EQUIPMENT AND MATERIAL					
SHREDDER	$	$250,000	E	$87,000	E
CONVEYORS	$	$214,000	E	$214,000	E
CHUTES/TRANSITIONS	$	$10,000	T	$10,000	T
EXPLOSION VENTS	$	$0	E	$27,210	CH*E
DUST CONTROL	$	$25,000	E	$25,000	E
MOTOR CONTROL CENTER	$	$13,450	AB	$13,110	AB
ACCESS PROVISIONS	$	INCLUDED		INCLUDED	

76	CONTROLS	$		$1,240	H*E	$619	M*E
77	SPARES	$		$27,600	A	$342	A
78	BLAST WALLS	$		$0	E	$18,000	M*E
79	FOUNDATION	$		$3,170	C*E	$6,220	C*E
80	STRUCTURAL SUPPORTS	$		$[illegible],000	E	$4,000	E
81	VIBRATION ISOLATION	$		$0	E	$2,000	E
82	TOTAL E&M	$		$548,460		$407,500	
83							
84			FIELD				
85			INST				
86	INSTALLATION		FACTOR				
87	SHREDDER	$	1.12	$30,000	C*E	$10,440	C*E
88	CONVEYORS	$	1.64	$136,960	C*E	$136,960	C*E
89	CHUTES/TRANSITIONS	$	2.00	$10,000	C*E	$10,000	C*E
90	EXPLOSION VENTS	$	1.80	$0	E	$21,770	CH*E
91	DUST CONTROL	$	1.69	$17,250	C*E	$17,250	C*E
92	MOTOR CONTROL CENTER	$	1.20	$2,690	C*E	$2,620	C*E
93	ACCESS PROVISIONS	$	1.70	$0	E	$0	E
94	CONTROLS	$	N/A	$513	M*E	$257	M*E
95	SPARES	$	1.00	$0		$0	
96	BLAST WALLS	$	N/A	$0	M*E	$32,400	M*E
97	FOUNDATION	$	N/A	$5,180	C*E	$10,170	C*E
98	STRUCTURAL SUPPORTS	$	1.80	$3,200	E	$3,200	E
99	VIBRATION ISOLATION	$	1.50	$0	E	$1,000	E
100	TOTAL INSTALLATION	$		$205,790		$246,070	
101	TOTAL EQMT, MATL, LABOR	$		$754,250		$653,570	
102	ENGINEERING/CONST SUPERVISION	%INST	12%	$90,510		$78,430	
103	MANAGEMENT RESERVE	%INST	15%	$126,710		$109,800	
104	TOTAL CONST COST	$		$971,470		$841,800	
105	FINANCING COSTS	%TOT	25%	$242,870		$210,450	
106	CAPITAL COST DURING CONST	$		$1,214,340		$1,052,250	
107	FOR A ONE YEAR CONST PERIOD,						
108	CAPITAL COST PER QTR IS:			$303,590		$263,060	
109							
110	PV AT DAY 0 OF CONST						
111	PHASE (APPLIES TO NAVY CASE) IS:			$1,142,100		$989,625	
112							
113	MAJOR EQUIPMENT REPLACEMENT COST	$		$673,210		$490,650	
114							
115	MAXIMUM PRACTICAL PROJECT LIFE	YEARS		24		24	
116							
117							
118	NUMBER OF EQMT REPLNTS IN LIFE	EACH		1		1	
119							
120	PV AT CONST DAY 0 EQUIVALENT TO FUTURE AMOUNT						
121	TO REPLACE EQMT 1ST TIME			$367,710		$268,000	
122							
123	PV AT CONST DAY 0 EQUIVALENT TO FUTURE AMOUNT						
124	TO REPLACE EQMT 2D TIME			$210,410		$153,350	
125							
126	PV AT CONST DAY 0 EQUIVALENT TO FUTURE AMOUNT						
127	TO REPLACE EQMT 3D TIME			$120,400		$87,750	
128							
129	PV OF MAJOR REPLACEMENTS						
130	AT CONST DAY 0 (APPLIES TO NAVY CASE):			$367,710		$268,000	
131							
132	FOR THE CHARLESTON CASE CAPITAL						
133	COSTS ASSOCIATED WITH ORIGINAL CONSTRUCTION						
134	ARE ASSUMED TO BE SUNK COSTS AND DAY 0 FOR THE						
135	PRESENT VALUE ANALYSIS IS DAY 0 OF OPERATIONS						
136	(NOT DAY 0 OF CONSTRUCTION AS IS THE NAVY CASE).						
137							
138	PV OF MAJOR REPLACEMENTS						
139	AT OPERATIONS DAY 0 (CHLSTN CASE):			$385,220		$280,760	
140							
141							
142							
143							
144							
145	OPERATING REQMTS						
146	ELECTRIC POWER						
147	SHREDDER DRIVE	KW/TON		3.14	T2-11	9.14	T2-11
148	LABOR OPERATING ONLY	MH/TON		0.1438	T2-13	0.1720	T2-13
149	LABOR ADMINISTRATIVE	MH/TON		0.0131	T2-13	0.0167	T2-13
150	TOTAL ANNUAL COST	$/YR		$21,350		$29,760	

151						
152	MAINTENANCE					
153	LABOR	MH/TON	0.0106	T2-13	0.0108	T2-13
154	TOTAL ANNUAL COST	$/YR	$871		$883	
155						
156	REPAIR					
157	LABOR	MH/TON	0.0114	T2-14	0.0106	T2-14
158	PARTS	$/TON	$1.51	T2-14	$0.63	T2-14
159	TOTAL ANNUAL COST	$/YR	$19,810		$8,750	
160						
161	THROUGHPUT/CAPACITY FACTOR/AVAILABILITY					
162						
163	AVG INFEED PER YEAR	TONS	12500	T2-7	12500	T2-7
164						
165	UNSHREDDABLES					
166	AS PERCENT OF INFEED	PCT	0.25%	T2-2	15.33%	T2-2
167	TOTAL ANNUAL DISPOSAL COST	$/TON	$269		$16,480	
168						
169	RDF					
170	ANNUAL PRODUCTION	TONS	12469		10584	
171	TOTAL ANNUAL VALUE	$/YR	$62,340		$52,920	
172						
173	SUMMARY, OVER OPERATIONAL LIFE EQUAL TO YEARS=		24		24	
174	AND:					
175	==		==========	=========	==========	=========
176	ALL PV'S BASED ON DAY 0 CONSTRUCTION					
177	WHICH WE BELIEVE IS BEST APPLIED					
178	TO THE NAVY CASE:					
179	PV AT DAY 0 COST OF ORIGINAL CAPITAL		$1,142,100		$989,620	
180	PV DAY 0 COST OF MAJOR EQMT REPLACEMENT		$367,710		$268,000	
181	TOTAL PV OF O&M, REPAIR AND DISPOSAL COSTS		5.17E+05		6.83E+05	
182						
183	TOTAL PRESENT VALUE OF RDF OVER OPTG LIFE		$746,880		$634,030	
184						
185	TOTAL NET PV COST PER TON MSW		$4.27		$4.36	
186	==		==========	=========	==========	=========
187	ALL PV'S BASED ON DAY 0 OPERATIONS					
188	WHICH WE BELIEVE IS BEST APPLIED TO THE					
189	CHARLESTON CASE WHERE CAPITAL COSTS					
190	ARE ASSUMED SUNK:					
191	PV AT DAY 0 COST OF ORIGINAL CAPITAL		$0		$0	
192	PV DAY 0 COST OF MAJOR EQMT REPLACEMENT		$385,220		$280,760	
193	TOTAL PV OF O&M, REPAIR AND DISPOSAL COSTS		5.69E+05		7.52E+05	
194						
195	TOTAL PRESENT VALUE OF RDF OVER OPTG LIFE, $		8.22E+05		6.97E+05	
196						
197	TOTAL NET PV COST PER TON MSW		$0.44		$1.12	
198	==		==========	=========	==========	=========
199						
200						
201	FOR INFLATION OF 5.00% AVERAGE PER YEAR:					
202	OPERATING, MAINT, DISPOSAL, REPAIR COST					
203						
204	1 ST YEAR OPTG, 20 YR AFTER CONST	0	4.23E+04	42300	5.59E+04	55873
205	2 ND YEAR	0	4.44E+04	44415	5.87E+04	58666
206	3 RD YEAR	0	4.66E+04	46636	6.16E+04	61600
207	4 AND SO ON...	0	4.90E+04	48968	6.47E+04	64679
208	5	0	5.14E+04	51416	6.79E+04	67913
209	6	0	5.40E+04	53987	7.13E+04	71309
210	7	0	5.67E+04	56686	7.49E+04	74875
211	8	0	5.95E+04	59521	7.86E+04	78618
212	9	0	6.25E+04	62497	8.25E+04	82549
213	10	$0	6.56E+04	65621	8.67E+04	86677
214	11	$0	6.89E+04	68902	9.10E+04	91011
215	12	$0	7.23E+04	72348	9.56E+04	95561
216	13		7.60E+04	75965	1.00E+05	100339
217	14	$0	7.98E+04	79763	1.05E+05	105356
218	15	$0	8.38E+04	83751	1.11E+05	110624
219	16	$0	8.79E+04	87939	1.16E+05	116155
220	17	$0	9.23E+04	92336	1.22E+05	121963
221	18	$0	9.70E+04	96953	1.28E+05	128061
222	19	$0	1.02E+05	101800	1.34E+05	134464
223	20	$0	1.07E+05	106890	1.41E+05	141187
224	21	$0	1.12E+05	112235	1.48E+05	148247
225	22	$0	1.18E+05	117847	1.56E+05	155659

226	23	$0	1.24E+05	123739	1.63E+05	163442
227	24	$0	1.30E+05	129926	1.72E+05	171614
228	25	$0	1.36E+05	0	1.80E+05	0
229	26	$0	[illegible]	0	1.89E+05	0
230	27		1.50E+05	0	1.99E+05	0
231	28		1.58E+05	0	2.09E+05	0
232	29		1.66E+05	0	2.19E+05	0
233	30		1.74E+05	0	2.30E+05	0
234	31		1.83E+05	0	2.41E+05	0
235	32		1.92E+05	0	2.54E+05	0
236	33		2.02E+05	0	2.66E+05	0
237	34		2.12E+05	0	2.80E+05	0
238	35		2.22E+05	0	2.94E+05	0
239	36		2.33E+05	0	3.08E+05	0
240	37		2.45E+05	0	3.24E+05	0
241	38		2.57E+05	0	3.40E+05	0
242	39		2.70E+05	0	3.57E+05	0
243	40		2.84E+05	0	3.75E+05	0
244	41		2.98E+05	0	3.93E+05	0
245	42		3.13E+05	0	4.13E+05	0
246	43		3.28E+05	0	4.34E+05	0
247	44		3.45E+05	0	4.55E+05	0
248	45		3.62E+05	0	4.78E+05	0
249	46		3.80E+05	0	5.02E+05	0
250	47		3.99E+05	0	5.27E+05	0
251	48		4.19E+05	0	5.53E+05	0
252	49		4.40E+05	0	5.81E+05	0
253	50		4.62E+05	0	6.10E+05	0
254	51		4.85E+05	0	6.41E+05	0
255	52		5.09E+05	0	6.73E+05	0
256	53		5.35E+05	0	7.06E+05	0
257	54		5.62E+05	0	7.42E+05	0
258	55		5.90E+05	0	7.79E+05	0
259	56		6.19E+05	0	8.18E+05	0
260	57		6.50E+05	0	8.59E+05	0
261	58		6.83E+05	0	9.02E+05	0
262	59		[illegible]	0	9.47E+05	0
263	60		7.53E+05	0	9.94E+05	0
264	61		7.90E+05	0	1.04E+06	0
265	62		8.30E+05	0	1.10E+06	0
266	63		8.71E+05	0	1.15E+06	0
267	64		9.15E+05	0	1.21E+06	0
268	65		9.60E+05	0	1.27E+06	0
269	66		1.01E+06	0	1.33E+06	0
270	67		1.06E+06	0	1.40E+06	0
271	68		1.11E+06	0	1.47E+06	0
272	69		1.17E+06	0	1.54E+06	0
273	70		1.23E+06	0	1.62E+06	0
274	71		1.29E+06	0	1.70E+06	0
275	72		1.35E+06	0	1.79E+06	0
276	73		1.42E+06	0	1.87E+06	0
277	74		1.49E+06	0	1.97E+06	0
278	75		1.56E+06	0	2.07E+06	0
279	76		1.64E+06	0	2.17E+06	0
280	77		1.72E+06	0	2.28E+06	0
281	78		1.81E+06	0	2.39E+06	0
282	79		1.90E+06	0	2.51E+06	0
283	80		2.00E+06	0	2.64E+06	0
284	81		2.10E+06	0	2.77E+06	0
285	82		2.20E+06	0	2.91E+06	0
286	83		2.31E+06	0	3.05E+06	0
287	84		2.43E+06	0	3.21E+06	0
288	85		2.55E+06	0	3.37E+06	0
289	86		2.68E+06	0	3.53E-06	0
290	87		2.81E+06	0	3.71E+06	0
291	88		2.95E+06	0	3.90E+06	0
292	89		3.10E+06	0	4.09E+06	0
293	90		3.25E+06	0	4.30E+06	0
294	91		3.41E+06	0	4.51E+06	0
295	92		3.59E+06	0	4.74E+06	0
296	93		3.76E+06	0	4.97E+06	0
297	94		3.95E+06	0	5.22E+06	0
298	95		4.15E+06	0	5.48E+06	0
299	96		4.36E+06	0	5.76E+06	0
300	97		4.58E+06	0	6.04E+06	0

301	98		4.81E+06	0	6.35E+06	0
302	99		5.05E+06	0	6.66E+06	0
303	100		5.30E+06	0	7.00E+06	0
304						
305						
306	FOR INFLATION OF 5.00% AVERAGE PER YEAR:					
307		RDF VALUE				
308	1	ST YEAR OPERATING, 2D YEAR AFTER DAY 0	6.23E+04	62340	5.29E+04	52920
309	2	ND YEAR	6.55E+04	65457	5.56E+04	55566
310	3	RD YEAR	6.87E+04	68730	5.83E+04	58344
311	4	AND SO ON...	7.22E+04	72166	6.13E+04	61262
312	5		7.58E+04	75775	6.43E+04	64325
313	6		7.96E+04	79563	6.75E+04	67541
314	7		8.35E+04	83542	7.09E+04	70918
315	8		8.77E+04	87719	7.45E+04	74464
316	9		9.21E+04	92105	7.82E+04	78187
317	10		9.67E+04	96710	8.21E+04	82096
318	11		1.02E+05	101545	8.62E+04	86201
319	12		1.07E+05	53311	9.05E+04	45256
320	13		1.12E+05	111954	9.50E+04	95037
321	14		1.18E+05	117551	9.98E+04	99789
322	15		1.23E+05	123429	1.05E+05	104778
323	16		1.30E+05	129600	1.10E+05	110017
324	17		1.36E+05	136080	1.16E+05	115518
325	18		1.43E+05	142884	1.21E+05	121294
326	19		1.50E+05	150029	1.27E+05	127358
327	20		1.58E+05	157530	1.34E+05	133726
328	21		1.65E+05	165407	1.40E+05	140413
329	22		1.74E+05	173677	1.47E+05	147433
330	23		1.82E+05	182361	1.55E+05	154805
331	24		1.91E+05	191479	1.63E+05	162545
332	25		2.01E+05	0	1.71E+05	0
333	26		2.11E+05	0	1.79E+05	0
334	27		2.22E+05	0	1.88E+05	0
335	28		2.33E+05	0	1.98E+05	0
336	29		2.44E+05	0	2.07E+05	0
337	30		2.57E+05	0	2.18E+05	0
338	31		2.69E+05	0	2.29E+05	0
339	32		2.83E+05	0	2.40E+05	0
340	33		2.97E+05	0	2.52E+05	0
341	34		3.12E+05	0	2.65E+05	0
342	35		3.27E+05	0	2.78E+05	0
343	36		3.44E+05	0	2.92E+05	0
344	37		3.61E+05	0	3.07E+05	0
345	38		3.79E+05	0	3.22E+05	0
346	39		3.98E+05	0	3.38E+05	0
347	40		4.18E+05	0	3.55E+05	0
348	41		4.39E+05	0	3.73E+05	0
349	42		4.61E+05	0	3.91E+05	0
350	43		4.84E+05	0	4.11E+05	0
351	44		5.08E+05	0	4.31E+05	0
352	45		5.33E+05	0	4.53E+05	0
353	46		5.60E+05	0	4.75E+05	0
354	47		5.88E+05	0	4.99E+05	0
355	48		6.18E+05	0	5.24E+05	0
356	49		6.48E+05	0	5.50E+05	0
357	50		6.81E+05	0	5.78E+05	0
358	51		7.15E+05	0	6.07E+05	0
359	52		7.51E+05	0	6.37E+05	0
360	53		7.88E+05	0	6.69E+05	0
361	54		8.28E+05	0	7.03E+05	0
362	55		8.69E+05	0	7.38E+05	0
363	56		9.12E+05	0	7.75E+05	0
364	57		9.58E+05	0	8.13E+05	0
365	58		1.01E+06	0	8.54E+05	0
366	59		1.06E+06	0	8.97E+05	0
367	60		1.11E+06	0	9.41E+05	0
368	61		1.16E+06	0	9.89E+05	0
369	62		1.22E+06	0	1.04E+06	0
370	63		1.28E+06	0	1.09E+06	0
371	64		1.35E+06	0	1.14E+06	0
372	65		1.42E+06	0	1.20E+06	0
373	66		1.49E+06	0	1.26E+06	0
374	67		1.56E+06	0	1.32E+06	0
375	68		1.64E+06	0	1.39E+06	0

Appendix M

LIST OF ACRONYMS AND NOMENCLATURE

APPENDIX M

ACRONYM/NOMENCLATURE LIST

ACLF	Air classifier light fraction
A_o	Availability, defined as $t_a/(t_a+t_b+t_c+t_d+t_e)$
CMR	Corrective Maintenance Ratio, defined as Mt_c/t_a
CC	Total cost of consumable supplies not included in CF
CF	Total cost of fuel used (virgin, waste oil, and electrical)
CL	Average cost of labor
CP	Total cost of parts used in repairs, maintenance, and replacement
FE	Ferrous
HRI	Heat Recovery Incinerator
MCRRF	Monroe County Resource Recovery Facility (at Rochester, NY)
MI	Maintainability Index, defined as $(Mt_b+Mt_c)/t_a$
MSW	Municipal Solid Waste
MTPF	Mean Time Between Failures, defined as t_a/N_f
MTBMA	Mean Time Between Maintenance Actions, defined as t_a/N_{ma}
MTTR	Mean Time To Repair, defined as R_p/N_r
Mt_a	Man-hours of effort during period t_a
Mt_b	Man-hours of effort during period t_b
Mt_c	Man-hours of effort during period t_c
Mt_d	Man-hours of effort during period t_d
Mt_e	Man-hours of effort during period t_e
NAVFAC	Naval Facility
NPV	Net Present Value
NYSERDA	New York State Research and Development Authority
N_f	Number of Failures that caused shutdown of the equipment
N_{ma}	Number of maintenanbce actions
N_r	Number of repairs
O&M	Operations and Maintenance
O/S	Trommel oversize at MCRRF
PMR	Preventative Maintenance Ratio, defined as M_{tb}/t_a
PV	Present Value
R	Reliability (in probability form), defined as $e^{-tm/MTBF}$
RAM	Reliability, Availability and Maintainability
RDF	Refuse Derived Fuel
R_p	Total active repair time spent on corrective maintenance
SCC	Specific Consumable Cost, defined as (CF+CC)/tons

SOM	Specific Operating Man-hours, defined as M_{ta}/tons
SPC	Specific Part Maintenance Costs, defined as CP/tons
SRM	Specific Repairs and Maintenance Man-hours, defined as $(Mt_b+Mt_c+t_e)$ tons
STM	Specific Total Man-hours, defined as $(Mt_a+Mt_b+Mt_c+Mt_d+Mt_e)$/tons
SWRC	Solid Waste Reduction Center (at Charleston County, SC)
TPD	tons per day
TPH	tons per hour
kwh/ton	kilowatt-hours/ton
n.a.	not available
rpm	revolutions per minute
t_a	Operational Period, includes t_{a1} and t_{a2}
t_{a1}	Operational Period during which shredder was energized and processing
t_{a2}	Operational Period during which shredder was energized and not processing
t_b	Period of time spent in routine maintenance
t_c	Period of time spent in repairs/replacements
t_d	Period of time shredder was de-energized, but operational
t_e	Period of time shredder was de-energized, but not operational
t_m	Mission time or period of time over which uninterrupted operation is desired
U/S	Trommel undersize at MCRRF

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